Plating

THE MONTHLY REVIEW OF THE AMERICAN ELECTROPLATERS' SOCIETY

JANUARY 1948

Volume 35 No. 1

In this Issue:

NICKEL-CHROMIUM PLATING PROBLEMS

POLISHING IN AUSTRALIA

ELECTROFORMING

PROPERTIES OF NICKEL PLATE

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With SPEE-D-BURR* "A TUMBLE FINISHING PROCESS"

* PAT. PENDING

GRADE A FINISH
Cost of producing this finish is 65-85% LESS than comparable complete wheel finish.

A A FINISH
Cost of producing this finish is 45-60% LESS than comparable complete wheel finish.

A A A FINISH
Cost of producing this finish is 40-50% LESS than comparable complete wheel finish.

Send us a sample of the work you are now wheel finishing and also a plated part to indicate desired finish.
We will advise you immediately the Saving you can make with the SPEE-D-BURR Process. Do not send us pieces which are too large for tumble finishing.

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This Belle of Ubangi received her gorgeous, glossy, durable, black complexion by a bath in Ebonol "Z". (A zinc base die casting designed by Martino.)

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Beautiful, adherent black oxide finishes can be applied to most metals by the Enthone Ebonol processes.

ebonol "S" Blackens iron and steel to give jet-black, ferro-ferric oxide coatings. Operating temperature, 285-290°F. Easy and pleasant to operate. Electroplated iron blackens readily.

ebonol "C" The quality black for copper, brass and copper alloys. Shiny or dull. Operating temperature, 210-220°F. Time 10 minutes. Electroplated copper blackens nicely.

ebonol "Z" A durable, deep, rich finish for zinc plate or zinc alloy castings. Dull or glossy oxide black coatings formed in from 5 to 10 minutes at 160-180°F

Write for literature and operating instructions. Samples of your work blackened without charge.

Enthone **INC. Metal Finishing Chemicals. 442 Elm St., New Haven, Conn.**

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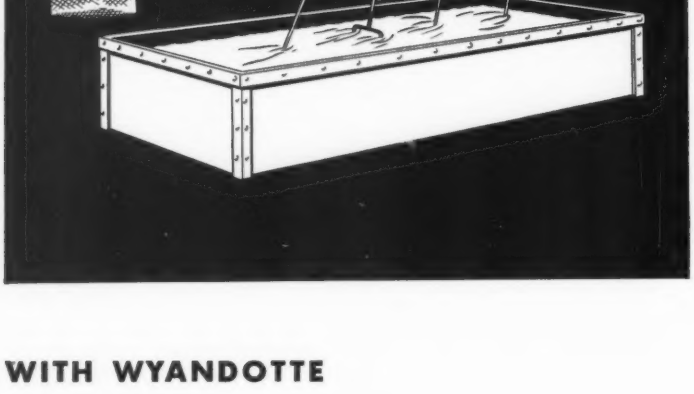

. . . WITH WYANDOTTE

EMLON SOLVENT-EMULSION

You get better and faster cleaning action, at lower cost, when you use this versatile new solvent-emulsion type cleaner. On actual production tests — due to the long life of Emlon solutions and the low concentrations at which Emlon is used — *savings of up to 50%* have been recorded.

Emlon is completely stable in hard water, and in acids and alkalies. It is free-rinsing and has anti-foam properties. Furthermore, it is non-flammable and nontoxic under normal conditions of use.

Ask your Wyandotte Service Representative about this unique metal cleaner and its many applications. Or write directly to us for a technical data sheet.

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WYANDOTTE, MICHIGAN • SERVICE REPRESENTATIVES IN 88 CITIES

Branch News

Coming Events

CHICAGO BRANCH

The Annual Educational Session and Banquet will be held in the Hotel Stevens on January 24.

The educational session will consist of a symposium on troubles encountered in copper plating by various processes and methods for correcting them. The following speakers are presented: MR. MERLE YOUNG, DR. A. K. GRAHAM, DR. M. M. BECKWITH, and DR. J. E. STAREK.

GRAND RAPIDS BRANCH

The Grand Rapids Branch will hold its Annual Educational Session and Dinner-Dance on Saturday, January 24, in the Pantlind Hotel.

With four excellent speakers presenting brand-new material, the Educational Session is expected to be exceptionally well attended. MR. R. M. WAGNER, Superintendent of Manufacturing Processes for Guide Lamp Division of General Motors Corporation, will present a paper, the title of which is as yet unannounced. MR. B. MARTIN of McGean Chemical Company will discuss the high-*p*H treatment of nickel plating solutions, a very timely subject on which there is very little in the literature. Since practically all platers use this method of treatment at one time or another, it will certainly be of universal interest.

DR. WALTER MEYER, Technical Director of Enthone, Inc., will furnish new material in his paper, "Preparation of Metals for Electroplating". DR. HAROLD J. READ, Associate Professor of Mineralogy at Pennsylvania State College, will offer a new subject in "The Microstructure of Thin Deposits".

The Dinner-Dance is proving to be as popular as ever. About 400 of the 470 available tickets were sold as of December 1. LYMAN B. SPERRY.

BALTIMORE–WASHINGTON BRANCH

The regular meeting of the Baltimore-Washington Branch was held on November 4 at the American Hammered Piston Ring Company.

The meeting was opened with a movie presented by DR. BRENNER of his trip to England, France, Belgium and Holland.

The guest speaker of the evening was MR. E. E. OATHOUT of the Behr-Manning Company of Troy, New York, who spoke about "Coated Abrasive Belts on Idler

Entered as second class matter July 1, 1946, at the Post Office at Philadelphia, Pa., under Act of August 24, 1916. Copyright, 1948, by the American Electroplaters' Society, Inc.

Backstand Assemblies." A short history of the use of abrasives and data on the efficiency of the coated belts was given. An interesting discussion was followed by a demonstration of polishing various metal samples on the backstand assembly which was set up in the plating shop. Samples and literature were also distributed by Behr-Manning representatives.

The Hammered Piston Ring Company was host in serving the guests beer, soft drinks, cold meats, chips, salad, and relish. Approximately 90 attended the meeting.

GRACE RIDDELL, *Secretary.*

BOSTON BRANCH

Four applicants were elected to membership at the meeting on November 6. There were also three new applications and one in-transfer.

Following considerable discussion the proposed increase in dues was approved 24 to 22 with 16 not voting. MANSON GLOVER was appointed chairman of the Boston Constitution Revision Committee. A suggested revision of the By-Laws affecting the Law Committee and its work was approved and referred to the committee for further action. ARTHUR W. COLLINS was appointed chairman of the Boston Research Fund Committee.

The Lindgren Library at Massachusetts Institute of Technology was approved as the local library for A.E.S. publications and the Secretary instructed to determine what past issues of THE MONTHLY REVIEW and *Proceedings* were missing and needed. A. W. GARRETT and G. P. SWIFT donated to this library all available material when the orignal library campaign was started.

The sale of the mailing list of the Branch to firms was finally approved. Three firms have been referred to the Branch by the Executive Secretary, DR. A. K. GRAHAM.

Librarian Manson Glover introduced MR. HUBERT GOLDMAN of Enthone, Inc., who presented an excellent paper on Electroplating on Aluminum. He traced the historical development of his subject from 1893 to the present day and described the major steps. Present day methods were described from three viewpoints: differential etching, porosity, and chemical deposition of a less reactive metal as a base. Cleaning cycles and acid treatments were described in detail as well as pretreatment methods. The metal deposition method was described most fully and was of most interest to the group; various methods of direct plating were also mentioned. Uses of electroplated aluminum base materials were described.

GEORGE P. SWIFT, *Secretary.*

BRIDGEPORT BRANCH

The regular business meeting on November 7, which was attended by forty-seven members and guests, was largely

FIRST COST SAVINGS
CAN VANISH LIKE BUBBLES

FIRST cost on your tanks is too low if early replacement cost is more than you save by skimping on corrosion-resistant materials and other design details that make for long tank life. Possibility of rapid wear-out is always a threat to profitable production.

Storts recommends making all specification decisions on the side of longer life and higher utility values, to cut maintenance costs and replacement costs—eliminating them at the source by means of adequate design and satisfaction-guaranteed construction.

Your requirements may call for a single tank replacement or for a complete new cycle of tanks—solid or lined with lead, rubber or brick—plus all fittings and accessory items. Storts' 25 years of specialized experience—gained by manufacturing many thousands of high quality tanks for plating and similar processing—can be valuable to you in determining the preferable specification for each unit. Whatever your needs may be, write us, wire us—or phone Meriden 5800.

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INCORPORATED
42 Stone Street Meriden, Conn.
Manufacturers of Welded Fabrications to Specification

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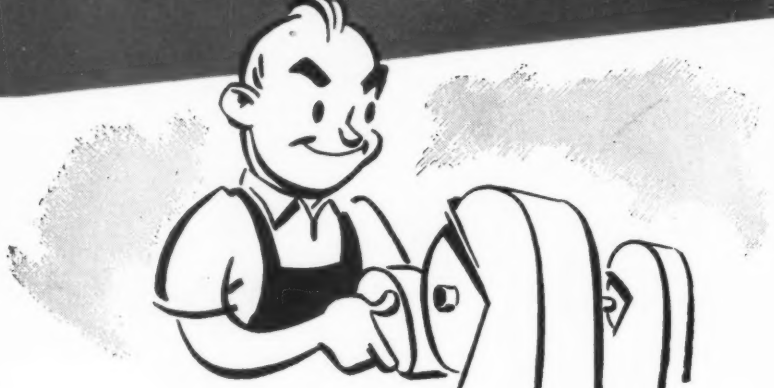
BUFF LESS

(or not at all)

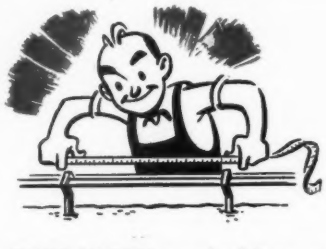
WITH UNICHROME COPPER



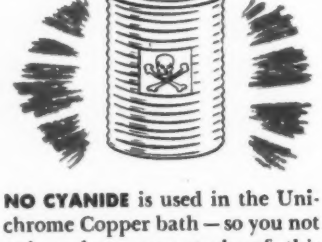
. . . and get BETTER, FASTER FINISHING, besides!

SMOOTH, DENSE DEPOSITS like Unichrome copper seldom need much coloring. That's why one shop could cut copper-buffing time from 3½ to 1 minute per bumper guard! Another plater reports *no buffing at all* on 5000 plated aluminum tubes. A third saves *half* his usual buffing compounds on Unichrome Alkaline Copper (imagine the savings in *time* and *work*)! And so it goes in hundreds of installations—smoother deposits give more output at less cost.

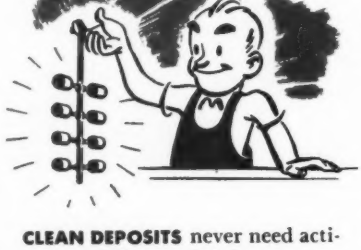
And yet you get still other outstanding advantages with this all-purpose bath. That's why we say: compare it with any other process, and we believe you'll specify Unichrome Copper every time! Write for helpful technical bulletin.



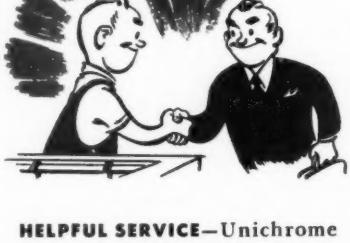
FEWER ANODES required, because the bath keeps them free of oxides even at high current densities. Why tie up extra money when Unichrome Copper has 100% anode efficiency—with 50% to 75% fewer anodes?



NO CYANIDE is used in the Unichrome Copper bath — so you not only reduce your stocks of this hazardous chemical, but get a safer bath as well.



CLEAN DEPOSITS never need activation. With no brighteners, no wetting agents used, Unichrome deposits come out clean, ready for the nickel cycle without special treatment.



HELPFUL SERVICE—Unichrome Copper is simple to maintain, seldom gives trouble. But should the need arise, you can always count on prompt help from our engineers and analytical laboratories.

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FOR SURFACES THAT SURVIVE

Chromium Plating • Porous Chromium • Unichrome* Copper
Unichrome Lacquers • Ucilon* Protective Coatings
Unichrome Stop-Off Lacquers and Compounds • Unichrome Dips
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devoted to committee reports and communications.

Six persons applied for membership. A class in electroplating has been formed. The delegates were instructed to vote NO on the amendment to raise the annual dues by $2.00.

A two-reel film, "Steel—Man's Servant", was shown by Librarian A. J. CHENIS. It illustrated the amazing development of the steel industry during the past twenty-five years.

JOSEPH G. STERLING,
Secretary-Treasurer.

BRIDGEPORT BRANCH

MR. PAUL M. GEIST, Patent Counsel of the Bullard Company, Bridgeport, Conn., was the featured speaker at the Open Meeting and Educational Session on November 21. Mr. Geist is a former Examiner in the Patent Office in Washington, D. C., a registered patent attorney, a member of the Court of Appeals for D. C., the American Bar Association, and the American Society for Mechanical Engineers.

His talk covered inventions and their protection under the laws. It traced the progress of a patent application through the Patent Office and dealt with such subjects as license agreements, patentability, infringement, and the trends of the law covering patent cases. The session proved most interesting and provoked considerable discussion.

Thirty-nine members and guests attended.

JOSEPH G. STERLING,
Secretary-Treasurer

CHICAGO BRANCH

Approximately 100 members and guests were present at the regular November meeting held at the Atlantic Hotel.

A very fine talk on the mechanics of barrel plating was given by MR. A. G. BIGNALL of Lasalco, Inc., who also showed a movie which fully illustrated the tumbling action which takes place in the barrel. At the end of the educational portion of the meeting, the speaker pleasantly surprised us with a film depicting the beauties of the Grand Canyon. All members had an enlightening and enjoyable evening.

J. H. MONAWECK, *Librarian.*

DAYTON BRANCH

In the last board meeting WALTER MOLINE was appointed General Chairman of our Third Annual Educational Sesson and Dinner Dance. This affair has become the center of interest of our entire yearly program. Those who have attended either of the preceding meetings will want to arrange to be with us next February 12. Mark this date on your calendar and watch this column for further details.

We were singularly honored by having A. E. S. Past President FRANK SAVAGE with us in our last regular meeting. The experience he added to our round table

Picture of Progress

ALODIZING Aluminum Regulator Covers in Mechanized Equipment.
Photograph courtesy of the Minneapolis-Honeywell Regulator Company

Alodizing — A NEW ORDER OF DURABILITY FOR ALUMINUM

CHEMICALS ACP PROCESSES

RUST PROOFING AND PAINT BONDING
Granodine *
Duridine *
Alodine *
Lithoform *
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RUST REMOVING AND PREVENTING
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PICKLING ACID INHIBITORS
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ALODIZING, the modern ACP chemical process utilizing "ALODINE"*, provides the utmost in protection for both painted and unpainted aluminum.

ALODIZING greatly increases aluminum's natural resistance to corrosion and transforms its surface into a durable bond for firm finish adhesion.

This new process requires no electricity—elaborate equipment—or high temperature. Operated effectively at 120° F., ALODIZING requires but 2 minutes for application by immersion, or 30 seconds when applied under pressure in a power spray washer.

Simple, rapid and economical, "ALODINE" makes high quality aluminum protection available to all industry and all types of production.

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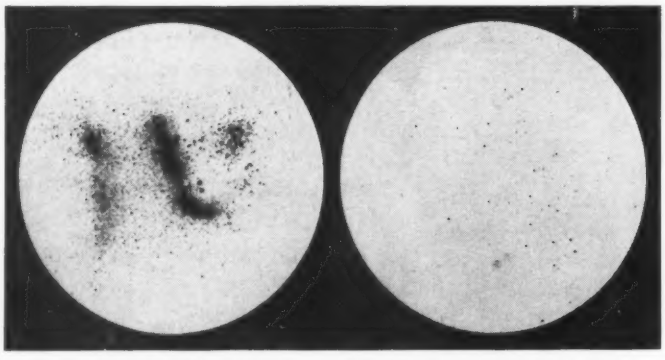
1. IMPROVE YOUR PLATING!
2. SAVE YOU MONEY!
3. INCREASE YOUR PROFITS!

DO YOU KNOW THAT NO-CRO-MIST

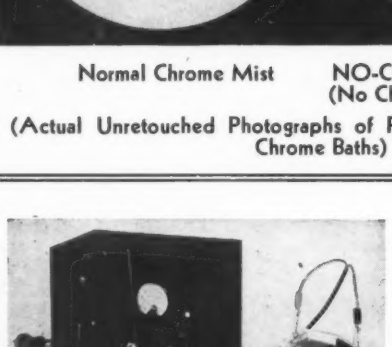


Normal Chrome Mist — NO-CRO-MIST BATH (No Chromic Acid Mist)

(Actual Unretouched Photographs of Paper Test of Mist from Chrome Baths)

(the unique, revolutionary soluble liquid product for control of chrome spray) WILL:

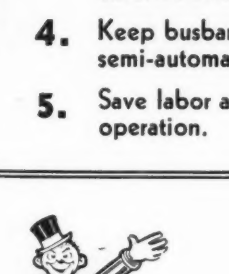
1. Eliminate chrome fumes from the plating room.
2. Drastically reduce building heating costs by reducing the volume (within the safety codes) of preheated air lost through chrome ventilators.
3. Save up to 95% (by actual test) of the chromic acid usually lost in the ventilator.
4. Keep busbars, racks, rack carriers for full or semi-automatics, ventilating systems cleaner.
5. Save labor and maintenance and give better operation.



SEE IT PLATE AND COVER!

For CONTROL of CHROME BATHS . . . THE LUCITE HULL CELL WITH FILTERED CIRCUIT RECTIFIER!

A 5-MINUTE PLATING TEST—using the Lucite HULL CELL with Filtered Circuit Rectifier—tells IMMEDIATELY whether the sulfate ratio is correct. If the ratio is not right, a few minutes' time tells exact additions to make to the plating tank for correction.



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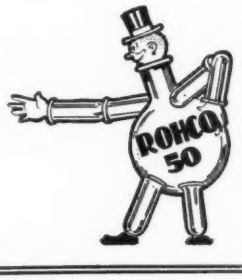
CADMIUM ADDITION AGENTS FOR PERFECT PLATING THAT FOR MORE THAN THREE YEARS HAVE GIVEN MAXIMUM:

1. Brightness, 2. Concentration Range, 3. Economy, 4. Ease of Control, 5. Throwing and Covering Power, 6. Freedom from Trouble.



YOUR PLATING DEPARTMENT NEEDS THESE PRODUCTS!!

Write TODAY, stating information desired on the ROHCO PLATING PRODUCTS described above. No obligation.

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"YOUR PLATING IS BEST WITH THE HULL CELL TEST"

discussion heightened the interest and increased the benefits of all those who attended.

We also had the pleasure of welcoming four new members of the Branch.

E. W. REHME, *Secretary.*

DETROIT BRANCH

Approximately 170 members and guests were present for the November 7 meeting.

Considerable discussion took place concerning the proposed amendment to increase dues, following which a vote indicated very definitely that the Detroit members were not in favor of this amendment.

After viewing an excellent color-sound motion picture entitled, "Wild Wings," the meeting was turned over to WALTER PINNER, who gave a very interesting and humorous account of his recent trip to Europe at which time he attended the Third International Electrodeposition Conference. Mr. Pinner briefly reviewed the 24 papers presented and then went on to give high-lights of English plating practice: most nickel baths are operated with air agitation and a large majority of steel work is plated with nickel directly; nickel deposition is carried out at ⅓ or ½ the current density usually practiced in this country; most English cleaning lines include an anodic sulfuric acid treatment.

Mr. Pinner closed with a description of English living conditions, touching upon the food, clothing, and export situation. He showed a large number of photographs which he had taken, many of which clearly depicted the extensive bomb damage still in evidence in England.

R. H. DUDLEY, *Publicity Chairman*

GRAND RAPIDS BRANCH

Thirteen applicants were elected to membership at the meeting on November 7.

M. R. CALDWELL was appointed Branch Research Committee Chairman.

The guest speaker was MR. GEORGE W. JERNSTEDT, Manager of Electroplating Projects, Westinghouse Electric Corporation, who presented a very fine talk on "Periodic Reverse Current Electroplating," accompanied by slides.

After a lively discussion, the meeting was closed with the usual buffet lunch served by the hotel. Approximately 60 members and guests were present.

JACOB M. HAGE, *Secretary.*

HARTFORD BRANCH

The regular monthly meeting on September 15 was attended by some 75 members and friends.

MR. L. CHESWORTH, Chief Chemist of the United Carr Fastener Corporation. Cambridge, Mass., spoke on Barrel Plating with Zinc and Nickel. He described some of the difficulties encountered and what

SIEFEN'S *NEW* LIQUID TRIPOLI

BUFFING
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T-132
FOR SPRAYING BUFFS WHILE REVOLVING ON LATHE TO PRODUCE MIRROR FINISHES ON ALL METALS. USE VERY SMALL AMOUNTS FOR BEST RESULTS. CAN BE LEFT IN SPRAY GUN WITHOUT CLEANING AS IT DOES NOT CLOG. MADE IN VARIOUS GRADES FOR VARIOUS METALS.
J. J. SIEFEN COMPANY
Polishing Experts

T-132 *Cuts Faster*

TESTED AND APPROVED BY MANUFACTURERS FOR BUFFING THE FOLLOWING NON-FERROUS PRODUCTS* . . . . .

★ Extruded Aluminum Moldings

★ Zinc Die Casting Plumbing and Automotive Hardware

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*Manufacturers names will be furnished on request.

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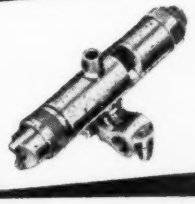

The Siefen spray gun is specially designed for use with the NEW Siefen Buffing Nu-Spra-Glu.

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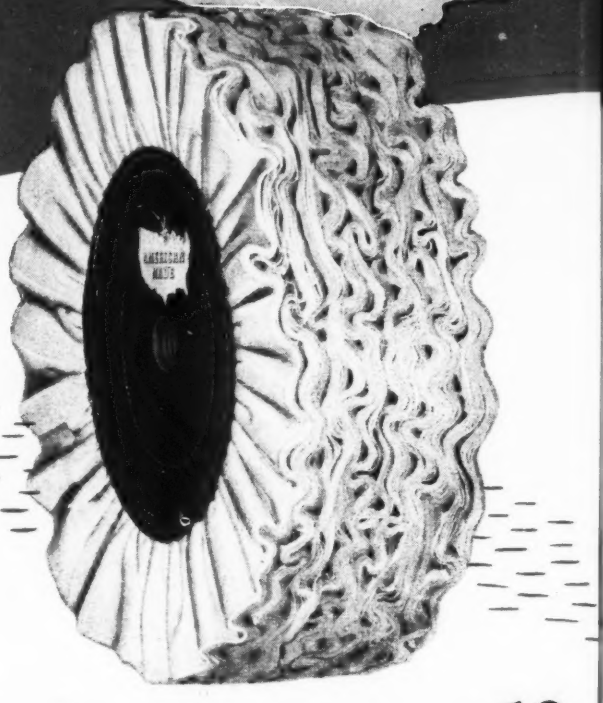
ONE SETUP

AMERICAN MADE



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Save Time – Save Money

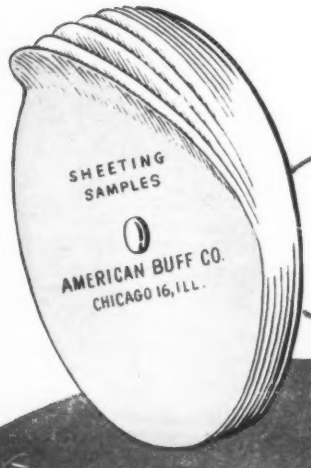
6 of these All-Purpose 14 inch Amflow Bias Buffs . . $10.

6 of 16 inch Diameter ONLY $12.50

4 inch Face — Both of 68/72 count — 2.73 Weight Sheeting

THIS OFFER FOR LIMITED TIME ONLY

The Amflow Bias Buff is a fast cutting buff when made of 68,72 Sheeting. It is versatile at various types of jobs . . . and it is very satisfactory for "coloring."



SEND FOR OUR MATERIAL SAMPLE WHEEL

Use this wheel of samples as a guide when ordering buffs or polishing wheels. Note the specifications on the discs. Compare the materials used in "American-Made" Buffs and Wheels with those used in other buffs. "Always Best – Compare."

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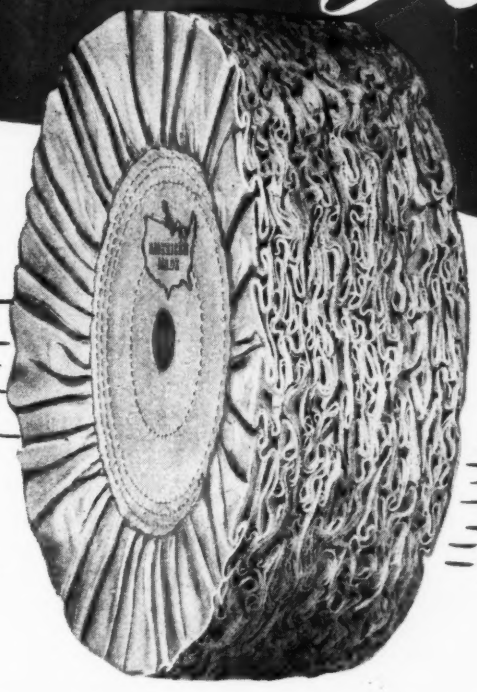
Trial Buff "Package"

ONE SETUP



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Save Time – Save Money

5 of these Famous 14 inch Shurflow Bias Buffs . . $10.

5 of 16 inch Diameter ONLY $12.20

4 inch Face — Both of 68/72 count — 2.73 Weight Sheeting

THIS OFFER FOR LIMITED TIME ONLY

The Shurflow Bias Buff is a faster cutting buff that will not ridge or streak the work, especially adaptable to spot purpose buffing on larger items. It is best on flat surfaces. Clip this Coupon and Mail Today

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☐ Ship us _____ set-ups of _____ inch Amflow Bias Buffs @
(Quantity) (Size)
$ _____ per set.

☐ Ship us _____ set-ups of _____ inch Shurflow Bias Buffs @
(Quantity) (Size)
$ _____ per set.

☐ Send us Wheel of Sample Materials

Company _____

Address _____

City _____ State _____

Ordered by _____

had been done to overcome them. A lengthy discussion period followed which indicated the interest shown.

GEORGE HOGABOOM, Hartford's guiding light, talked briefly on the International Electrodeposition Conference held in England this year.

A new feature at our regular meetings was introduced: the showing of sound movies on subjects closely connected with the work of the electroplater.

The usual refreshment period followed and was enjoyed by all.

A. J. DANKEVICH, *Secretary.*

HARTFORD BRANCH

The attendance at the regular monthly meeting on October 20 exceeded 70 members and friends.

DR. H. L. KELLNER of the Lea Manufacturing Co., Waterbury, Conn., discussed "Advances in Polishing and Buffing." With the aid of movies, he described the proper way of preparing a wheel and illustrated quite clearly how a wheel functions. During the discussion period, Dr. Kellner answered all the questions directed to him.

Movies were again shown; the great interest in them proves that they will be a permanent feature of our meetings.

GEORGE HOGABOOM talked about the several publications in the world that deal chiefly with electroplating. It was interesting to note that all the great countries are concerned about this science and are doing what they can to promote it.

Refreshments were served to conclude the meeting.

A. J. DANKEVICH, *Secretary.*

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Horizontal Plate
FILTERS
Because the filter cake is held horizontally, it is absolutely stable to the end of each filtering cycle. And cycles are longer because the cake retains its porosity longer. That is why the "horizontal principle," as embodied in Sparkler filters, gives you more efficient, low cost, operation. Sparkler filters are pressure-tight and leak-proof, designed for intermittent or continuous operation.
4 Plating Solution Types
1. Rubber-lined for bright nickel
2. Stainless steel for acids
3. All Iron for alkaline solutions
4. All Steel (with Stainless Pump) for chromium
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INDIANAPOLIS BRANCH

There were 48 members and guests in attendance at the October 1 meeting.

THOMAS EVANS invited the Branch to hold a "Ladies' Night" meeting in Columbus to take the place of our regular meeting in April, which was accepted.

A committee was appointed to investigate the feasibility of holding an educational session and dinner dance in the Spring. It will report at the next regular meeting. President Crawford appointed L. HESOUN and H. PHILLIPS, co-chairmen, E. BRUCK, L. WORRELL, C. NIEHAUS, and A. SCHMIDT.

Four applicants for membership were elected.

A committee composed of ROBERT LITTLE, A. M. MAX and WILLIAM CASTELL was appointed by President Crawford to consider the advisability of a "branch paper" presentation by the Indianapolis Branch

Librarian DR. A. M. MAX introduced MR. BERNARD C. CASE of the Hanson-Van Winkle-Munning Co. who gave a very informative talk on "Removal of Impurities from Nickel Plating Solutions." The questions following the paper indicated much interest in the topic.

J. MONAGLE, *Secretary-Treasurer.*

INDIANAPOLIS BRANCH

About 50 members and guests attended the regular meeting on November 5.

An educational session and dinner dance will be held in March. A committee was appointed to determine cost, location, and to formulate plans. Committee members are: L. HESOUN and H. PHILLIPS, Co-chairmen, E. BRUCK, M. MALVASE, L. WORRELL, and A. SCHMIDT.

Two applications for membership were approved.

DR. A. M. MAX, our Librarian, introduced the guest speaker, Mr. C. F. NIXON of Fisher Body-Ternstedt Division, General Motors Corporation, whose topic was "Nickel and Chromium Plating." He described the steps most essential for successful plating of copper, nickel and chromium in one continuous cycle, stressing in particular the importance of good rack design, rack coating, solution control and purification, and treatment of racks between unloading and loading stations.

A lively discussion period followed.

J. MONAGLE, *Secretary.*

LANCASTER BRANCH

A steak dinner given by the American Wire Fabrics Corporation, Mt. Wolf, Pa., preceded the regular monthly meeting on November 7 at the Conewago Inn, nine miles north of York, Pa. Forty-one members and guests were present.

CHARLES SNYDER was reappointed chairman of the Research Committee for the Branch. It was moved and seconded

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to donate $50.00 to the committee in charge of the Ladies Night affair to be held in December. Two applications for membership were approved by the members, and three applications were referred to the Board of Managers.

President THEODORE SCHWALM introduced our speaker, MR. KENNETH M. HUSTON, Senior Research Engineer for the American Rolling Mills Co. and A. E. S. President. Mr. Huston spoke on "Finishing Methods for Stainless Steel." His talk included practical suggestions for grinding, polishing, buffing, blackening, electropolishing, and tumbling. Following his talk, Mr. Huston then answered numerous questions about the affairs of the Society.

H. CLAY BRUBAKER, *Secretary*.

LOS ANGELES BRANCH

The November 10 meeting was held at Scully's with 82 present, including visitors.

DON BEDWELL reported for the New Constitution Committee, covering their recommendations to CLYDE KELLY, Western District Co-ordinator. LEO ATIMION was appointed Chairman of the Research Committee. Eight new members were received.

MR. ROBERT H. LONGACRE, Advertising Manager of *Western Finishing*, a new magazine first published in September by the Lindley Publishing Co. of Los Angeles, told how and why the magazine was originated, what it will cover, and what it proposes to do for the finishing industry in the 11 western states.

"The Air We Breathe," a film illustrating the development and proper application of Comfo respirators, was shown by MR. JAMES HAGARMAN of Mine Safety Appliance Co. Following the film, MR. GEORGE HENDERSON, also of Mine Safety Appliance Co., spoke on "Safety and Safety Equipment in the Plating Room," describing particularly respiratory hazards and substances that might cause skin irritation. He also described the operation of samplers used in the determination of impurities in the air and equipment for removing these impurities.

During the question-and-answer period the following questions came up:

Q1. What causes deposition of gold plate of different colors even when the same solution temperature and voltage are used? A: Variations in anode area and degree of agitation will affect the color of gold plate.

Q2. What may be used to oxidize brass to produce a permanent deep black color other than butter of antimony or liver of sulfur? These films rub off. A: Use iron chloride-muriatic acid-arsenic, dip in liver of sulfur and repeat. This film should be lacquered to protect it. It was also suggested that one of the molyblack processes be tried.

Q3: How can one produce a crystal finish on brass other than by using copper sulfate? A: Use an old, worn out bright dip to which sal ammoniac has been added. This will work on cast brass but is no good on sheet brass. Use of an aqueous solution containing sodium dichromate, 12 oz/gal, and sulfuric acid, one pint/gal. was also recommended.

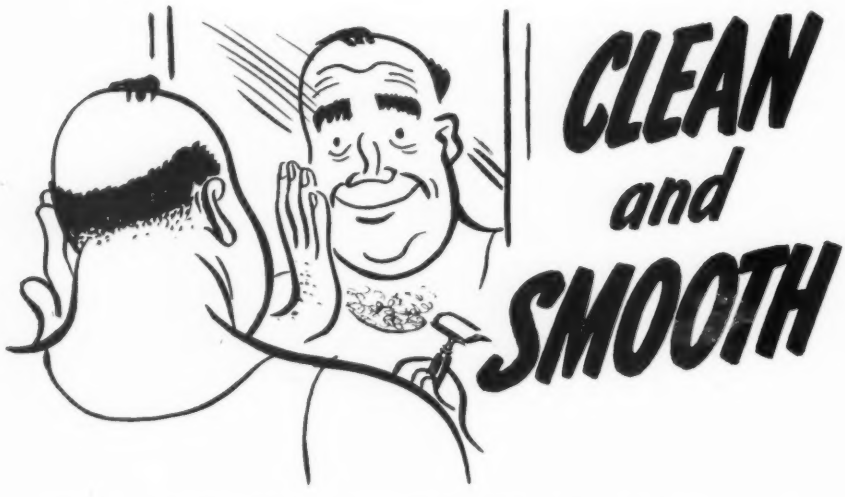
DEAN WILLIAMS, *Secretary*.

MONTREAL BRANCH

MR. J. D. FAIRBAIRN gave a very instructive talk on thickness measurement of plated deposits at the November 4 meeting, giving details of five different methods: direct measurement, timing of a chemical reaction, weight loss on stripping, magnetism, and electrolytic means. Demonstrations followed of the timing method and the Magne-gage. The Branch is very grateful to Mr. Fairbairn for his efforts and to the R. C. A. Victor Co. for use of the equipment.

The Constitution amendments suggested by the branch committee were read and approved by the Branch.

WM. GLOVER, *Secretary*.



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Sodium Metasilicate
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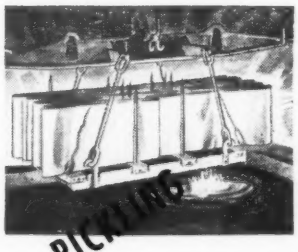

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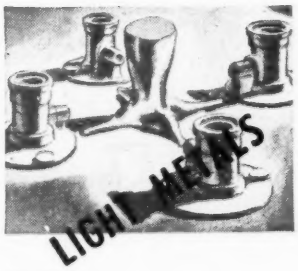

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Branch News

NEWARK BRANCH

Forty-five members and guests were present at the meeting on October 3.

Mr. Fisk of the Community Chest Drive in Newark opened the meeting with a short talk supplemented by a ten minute sound-movie film which illustrated some of the activities of benefited groups.

Mr. Faint again appealed for back copies of The Monthly Review for the Newark Public Library.

Mr. Louis J. Donroe of the Royal Plating and Polishing Company delivered a very interesting paper on "New Horizons In Electroplating": electropolishing of brass, silver, and aluminum; plating bright deposits from silver, copper, gold, and brass solutions; improved cathode efficiency of chromium baths; special electrodeposits such as of stainless steel and selenium; improved methods for control of spotting out on deposits from certain baths; direct plating on zinc base die castings, etc. A lively discussion followed his talk in which many in the audience took part.

Three new applications for membership were presented. Six new members were elected.

S. S. Frey, *Recording Secretary*.

NEWARK BRANCH

At the October 17 meeting, Mr. F. J. MacStoker of the New York Branch, coordinator for the area, requested action on the selection of representatives from the Branch for discussion of proposed changes in the A. E. S.'s Constitution. President Cobb appointed Librarian Irenas to call a special joint session of the Educational Committee and the Board of Managers to act on this matter at an early date.

Three new applications for membership were received. Three men were elected to membership.

Dr. Price, Technical Director of the Oakite Products, Inc., presented an excellent talk on the "Chemistry of Wetting Agents." It was illustrated by numerous slides and by wooden models depicting the position of the atoms within the molecules of wetting or surface active agents. A mechanism for their action in the removal of oil from surfaces was proposed. Most of the synthetic detergents have been developed only within the last fifteen years. Their application in the electroplating field resulted from their successful use in the textile industry. One way of classifying these materials is to determine the residual charge existing on the hydrophilic, or waterloving, part of the molecule. When the charge is positive, they are called anionic; negative, cationic; and when there is no charge, non-ionic. Dr. Price's approach to the subject from a historical background, his giving a simple picture as to how some of the wetting agents are prepared, and his showing how they have aided the electroplater in his work was excellent. The talk was followed by a period of questions and answers, in which the audience took part most enthusiastically.

S. S. Frey, *Recording Secretary*

NEWARK BRANCH

The death of Mr. William F. Hodecker, Sr., age 81, a past member of the A.E.S. for many years, was announced at the November 7 meeting. The one-minute silence with the group standing was a tribute to his memory.

The desire of the Educational Committee for the next National Convention to secure papers on Barrel Plating, Tumbling, and Electrolytic Polishing as the main attractions was announced.

Two new applications for membership were received, and three men were elected to membership.

A report was made by the Branch Committee for Proposed Changes in National Constitution of the A.E.S. The following recommendations were adopted by the committee: 1. Retain the present name of the Society. 2. Make changes so that a person may join the Society without being assigned to a Branch, but penalize him by reducing his privileges, such as voting, etc. 3. Retain the present set-up for collecting dues. 4. Support the new amendment to constitution which allows for an increase in the per capita tax from $2.70 to $4.70 and raises the minimum dues to $8.00.

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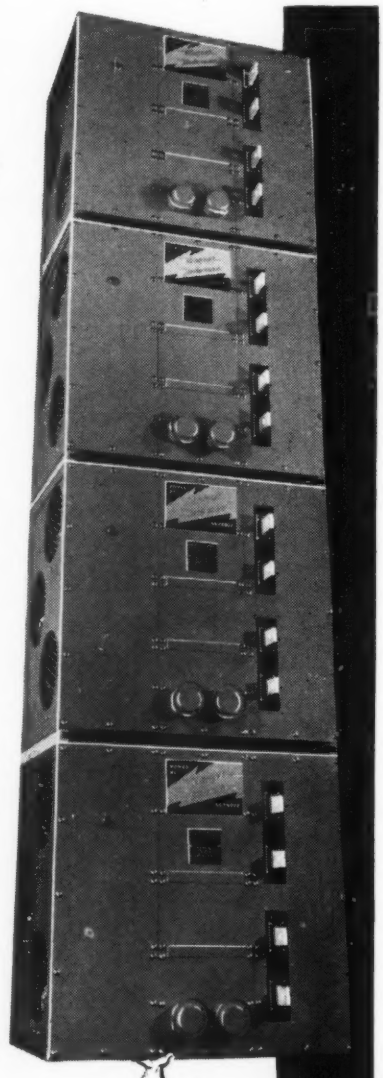

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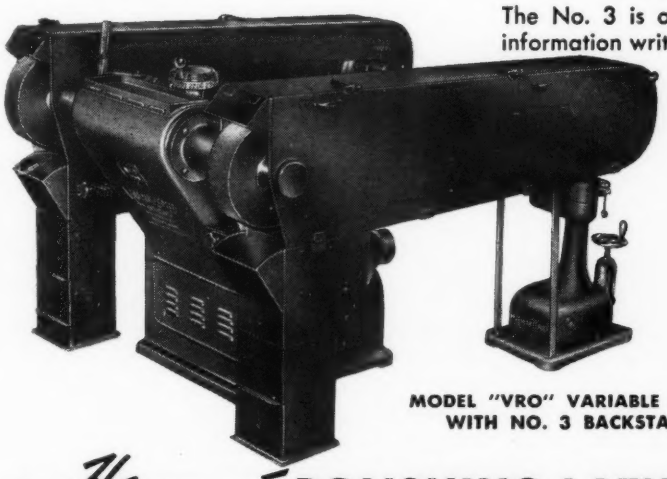

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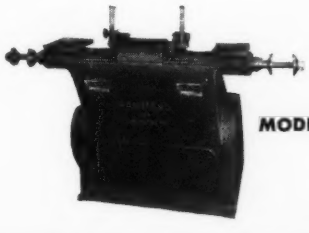

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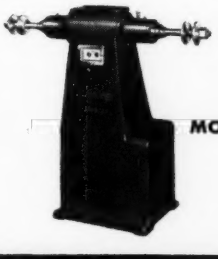

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MR. URBAN MULLIN of the Wright Aeronautical Corporation presented a fine paper on "Bronze Plating." He pointed out that this type of alloy coating is needed in the nitriding of certain kinds of steel since nickel and tin deposits have some limitations for successful operation. The bath formulas, operating conditions, stripping solution formula, and characteristics of the deposits used in his plant were given. A discussion period followed. Samples of a bronze plated bearing and Hull Cell panels as well as photomicrographs of the coating were viewed by those present.

Eighty-five members and guests were present. S. S. FREY, *Recording Secretary*

NEW HAVEN BRANCH

The New Haven Branch held its first monthly meeting of the season in the Sterling Laboratory of Yale University on September 16.

PRESIDENT EDGAR LUTHER appointed the following Committees:

Research: C. F. Gurnham, E. R. MacNicholl, M. A. Orr, H. B. Smith, and G. G. Knecht.

Membership: W. T. Lynch, H. M. Barnard, R. T. Sammet, W. E. Bridgett, and C. Garner.

Sick: J. W. English, J. M. Barry, and W. A. Montgomery.

Exhibit: C. Garner, H. J. Creamer, J. V. Sullivan, G. A. Tracchio, and G. G. Knecht.

Budget: A. Rosenthal, H. L. Kellner, and C. Garner.

DR. KELLNER reported on the audit of the Branch's books and submitted suggestions from the Budget Committee on savings to be made this coming year. The report was accepted.

Librarian HENRY B. SMITH introduced MR. THEODORE VOYDA, Chief Chemist, Apothecaries Hall Company, Waterbury, Conn. Mr. Voyda spoke about Nickel Anodes and presented slides which gave a most interesting picture of their manufacture, structure, and application. The lively discussion indicated how much the members appreciated the talk.

B. J. GAFFNEY, *Secretary-Treasurer.*

NEW HAVEN BRANCH

PRESIDENT E. C. LUTHER opened the meeting of the New Haven Branch on October 14 by hearing the committee reports.

DR. C. FRED GURNHAM, Chairman of our Research Committee and Educational Chairman, spoke on research and introduced A. E. S. SECOND VICE-PRESIDENT ARTHUR W. LOGOZZO of the Nutmeg Chrome Corporation, Hartford, Conn. Mr. Logozzo first discussed the revision of the Constitution, the proposed increase of dues, etc. He then presented a paper on "Bright Nickel and Decorative Chrome Problems". Being a practical plater, Mr. Logozzo was able to present his subject so it could be clearly understood by both supervisor and plating operator. Using slides, charts, and his many years of plating experience, he was generous in showing the set-up in his own plant. A lengthy question period followed.

B. J. GAFFNEY, *Secretary-Treasurer.*

NEW YORK BRANCH

One new application for membership was received at the November 14 meeting.

MR. LIONEL DE WALTOFF, of Chemclean Products presented a resume of recently published literature relative to our field. A lively question and answer session followed.

ALBERT FUSCO, *Recording Secretary.*

NEW YORK BRANCH

President GEORGE SCHORE opened our meeting on Friday, November 28, when two new applications for membership were received and two new members elected.

Our speaker for the evening was MR. SIDNEY A. LEWIS of U. S. Stoneware. Mr. Lewis' talk, entitled "Corrosion Resistant Materials," described the various organic materials available for corrosion protection in the plating room, with specific references to floors, walls, racks, equipment and tank linings.

ALBERT FUSCO, *Recording Secretary.*

PROVIDENCE-ATTLEBORO BRANCH

MR. DANIEL GRAY of Oneida, Ltd., presented a detailed and complete story on the Electropolishing of Silver in Cyanide Solutions at the November 17

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The attendance was sixty-two.

EDWARD A. PARKER,
Secretary-Treasurer.

ROCHESTER BRANCH

MR. FRANK SMITH, President of Technic Inc., Providence, R. I., was the featured speaker at the November 21 meeting. His talk on Gold and Gold Alloy Electroplating was comprehensive and well presented and justified the unusually large turn-out of 60 members and guests. Some unusual features of precious metal deposition and the need for perfect preparation of the basis metal were emphasized.

There were four applications for membership. CECIL THORNTON was re-appointed Chairman of the Branch Research Committee and will appoint his own committee.

The Joint Session with Buffalo, Toronto, and Syracuse Branches will be held in April in the Hotel Seneca. WILLIAM TUCKER was elected chairman, JOE HULL will be in charge of advertising, and JOHN Q. ADAMS in charge of the Program Committee.

The Branch voted to admit as members students in Metal Finishing at Rochester Institute of Technology.

JAMES WEAVER, *Secretary*

ST. JOSEPH VALLEY BRANCH

Forty members and guests attended the regular meeting in the Empire Room of Hotel Elkhart on November 5.

Three new members were elected and two applications were received. The Secretary reviewed the recommendations of the officers relative to the proposed Constitutional changes.

LIBRARIAN V. E. PETERSON introduced MR. JOSEPH M. ANDRUS, Chief Chemist of Croname, Inc., of Chicago who gave an excellent talk on "Anodizing of Aluminum". Comparisons of the three common solutions were made, and slides were used to illustrate the talk. Mr. Andrus was given a rising vote of thanks after an extensive question period.

Refreshments were then served to the members and guests in buffet style.

HAROLD J. WIESNER,
Secretary-Treasurer.

ST. JOSEPH VALLEY BRANCH

Thirty-eight members and guests attended the dinner and forty-five were present at the business and technical session on December 3.

Four new applications were received; two applications were voted upon favorably by the members.

PRESIDENT W. S. MCDOWELL asked FIRST VICE-PRESIDENT J. M. HEDGES to name his committee for Research. He appointed L. E. WEEG and R. D. WYSONG. As Chairman of the Membership Committee, Mr. Hedges asked M. G. BEREMAND, A. LIGHT and J. CUSHING to serve. SECOND VICE-PRESIDENT R. FRIEND requested O. E. ADLER and WILLIAM MCDOWELL to serve as Co-chairmen of the Social Functions Committee.

The meeting was then turned over to LIBRARIAN V. E. PETERSON who introduced MR. W. E. MOLINE, National Cash Register Company, Dayton, Ohio, who gave a talk on "Effective Solution Control and Maintenance for Production". The subject matter covered control of cyanide copper, bright nickel, chromium, and zinc plating baths. Mr. Moline stressed the importance of regular analyses and additions to the bath in order to keep the solutions at their optimum operating efficiency. An interesting question and answer period followed.

HAROLD J. WIESNER,
Secretary-Treasurer.

SAN FRANCISCO BRANCH

The regular meeting on November 13 was attended by 11 members. J. R. PATTENGER, Chairman of the Entertainment Committee for the Annual Dinner-Dance, made a report on arrangements for the

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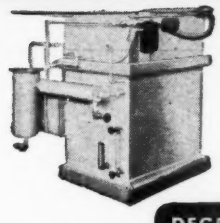
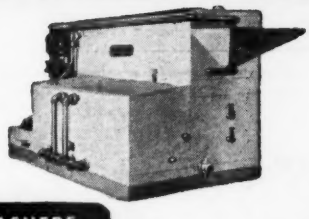

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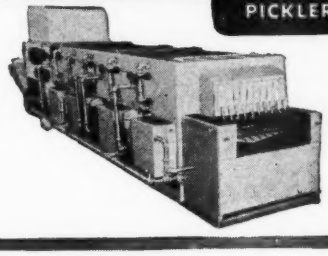
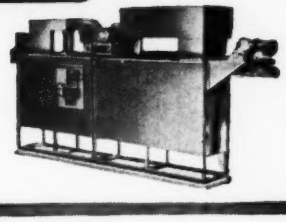

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party. Due to limited facilities at the club, attendance is being limited to 100. In the event of a deficit, an assessment will be made in January.

JACK HITE, *Secretary-Treasurer.*

SOUTHEASTERN BRANCH

Our November meeting was held at the Robert Fulton Hotel, Atlanta, on the 13th. We enjoyed a very interesting talk by DR. H. L. KELLNER of the Lea Manufacturing Co., of Waterbury, Conn. His topic was "Buffing and Polishing," and his presentation was enjoyed by the 22 members and guests who attended. Dr. Kellner also touched on the matter of Sustaining Members and was promised that the Branch would do all in its power to bring in its quota at the earliest possible date.

WM. T. WEYMOUTH, *Secy-Treas.*

SPRINGFIELD BRANCH

The meeting on November 24, due to illness of President ERNEST COUTURE, was presided over by Vice President JOHN COSTIGAN.

Two applicants were voted into the Society.

DR. GARDNER FOULKE of the Hanson-Van Winkle-Munning Co., Matawan, New Jersey, gave a very interesting talk on "P. R. Process Plating." A general discussion followed.

LAURENCE R. FOUNTAIN, *Sec'y-Treas.*

SYDNEY BRANCH

The fortieth regular meeting on October 14 was attended by 28 members and visitors.

During the business session one new member was elected, and one member, R. N. Whale, tendered his resignation as he had reached the age of retirement from active participation. The resignation was accepted with regrets, and the Secretary was instructed to express the appreciation of the Branch to Mr. Whale for the work that he had done for the trade in Sydney.

Plans for the Annual Social in December were well in hand, and the Secretary reported that the Branch also had plans well under way for the publication of a Sydney Branch Year Book which was expected to be forwarded to members early in the new year.

The speaker for the evening was DR. PINCAS, who took as his subject "Bright Nickel Plating." Considerable discussion followed.

J. R. GODFREY, *Secretary.*

TOLEDO BRANCH

A regular monthly meeting was held on November 6 in Commodore Perry Hotel.

Seven applicants were accepted into membership. It was decided to invite interested students at Toledo University to attend our meetings. It was also decided to have the meeting notice put in the Toledo paper, and try to have it announced over the local radio. Future meetings will be held in Commodore Perry Hotel.

MR. WILLIAM JACKSON, Engineer in charge of plating barrels and auxiliary equipment at the Udylite Corporation, Detroit, Mich., gave a very interesting talk on plating barrel layouts and their use.

G. P. H. BERGEMAN, *Secretary.*

TORONTO BRANCH

The October meeting was held in Hamilton, Ontario, in order to give impetus to the formation of a new branch in that city. Canadian Westinghouse Company had offered the use of its auditorium for this meeting, an offer which was gratefully accepted.

MR. BUTTERILL of The International Nickel Company gave a talk on Corrosion Resistance. A discussion followed on the details of starting a branch from which, we hope, the Hamiltonians gathered some useful information from the Torontonians.

In November we had the pleasure of hearing MR. G. J. BERRY of the Electric Products Company, Cleveland, Ohio, on motor-generators vs. rectifiers. The talk was entitled, "More for Less". As we had heard the other side of the picture from Mr. Poettinger of Canadian Westinghouse at the September meeting, this talk on motor generators neatly balanced the account: now no one who heard both talks knows what to believe. In January, we are to hear a discussion by an engineer with Canadian Hanson & Van Winkle Company, Ltd., which sells both generators and rectifiers.

The Toronto Branch has six members in England and, feeling that they should get something out of their membership besides cold hard facts, the Branch decided to send each a parcel of the kinds of food which are still impossible to procure in England. These parcels were sent in time to reach England before Christmas.

On November 26, the Branch held its Annual Fall Dance in the spacious and pleasant "Club Kingsway" in the nearby suburb of Swansea. We rented the hall for the evening, and the dance was well attended and well organized. The perennial organizer of such affairs, B. J. CAMERON, is again due for many thanks and much appreciation. There were numerous prizes, big and little, donated to the Branch for the dance, and we were honored by having the Mayor of Swansea assist in the presentations.

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Editorial

January 1948

THE PLATING INDUSTRY

ONE FREQUENTLY hears of the *plating industry* but few realize what this expression covers. The Government, for example, when it classifies manufacturing industries, includes under "Electroplating, plating, and polishing", establishments *primarily* engaged in this enterprise, i. e., the job and contract shop. Others may think of the supply houses who manufacture and sell plating equipment and supplies. But actually these groups represent only a small part of the industry.

Preliminary studies of the information furnished by A. E. S. members and other subscribers to Plating show the plating industry to be almost synonomous with the metal working industry. Here are Ordnance and Accessories; Furniture and Fixtures; Printing and Publishing; Primary Metal Industries; Fabricated Metal Products; Machinery; Electrical Machinery; Equipment and Supplies; Transportation Equipment; Instruments, Photographic and Optical Goods, Watches and Clocks; and Miscellaneous Manufacturing Industries, to mention only major classifications. The plating industry also, to some extent, spills over into the plastics industry, the leather industry, the wood industry, and others.

The immense variety of consumer and capital goods, produced by these industries, that are finished by plating and allied processes, testify to the plating industry's vital importance.

Gustaf Soderberg

NIXON

OLSEN

about the authors

Mr. Nixon is Director of Process Engineering at Fisher Body-Ternstedt Division of General Motors Corporation with which he has been connected since 1929. He graduated in 1923 from University of Wisconsin, where he studied under Dr. O. P. Watts, and was for six years with Western Clock Company. His outstanding contributions to the development of electroplating include recognition of the importance of drag-out and means of measuring it, introduction of copper undercoatings in the nickel-chromium plating of zinc base die castings, and development of testing methods for plated zinc base die castings.

Dr. Olsen studied at Michigan State College under Dr. D. T. Ewing and received his Ph.D. degree from that institution in 1936. He was Supervising Engineer of Plating at the Fisher Body-Ternstedt Division until the Fall of 1947 when he became Professor at the Pacific Lutheran College, Parkland, Washington.

about the article

Notes on Nickel and Chromium Plating

C. F. NIXON AND R. C. OLSEN

THE PRESENT TREND in electroplating is toward thicker deposits. Exposure tests and reports on service failure of plated parts both emphasize that durability of the plated finish depends to a large degree on the thickness of the plate. And automobile owners, particularly, want durability. As a consequence, thicker deposits are called for now than were specified before the war; one automobile manufacturer states in advertisements that plate thickness has been doubled; in a joint industry conference sponsored by General Motors on Zinc Base Die Casting Quality it was suggested that out-of-door plated parts should be good for five years; a producer of nickel advertises in a recent issue of a national magazine that thicker nickel plate makes bumpers stay shiny longer.

Quality with Low Cost

The price of the finished product, however, remains important. The plater is called upon in no uncertain terms to produce the demanded improvement with a minimum increase in cost. Study of improved bright and semi-bright nickel and copper deposits has been stimulated as has been the study of other means for reducing finishing cost. As the results of these investigations become available for adaptation to production plating, it becomes necessary to grapple with the problems the new baths and methods bring with them.

It is the purpose of this paper to present notes on our experience at the Fisher Body-Ternstedt Division of General Motors Corporation in depositing chromium over bright nickel plate in the same plating machine or, if a plating machine is not involved, without re-racking through a sequence of still tanks.

The cost cutting advantages of the procedure are evident. Labor required is reduced because less racking and unracking and other handling is necessary. Fewer racks are needed for a given volume of pro- Because bright nickel immediately chromium ... cleaning, fewer tanks and consequently required. Perforce, usually, interposed operations are eliminated. However, technical difficulties are introduced. Though fewer racks are needed, those used must be good; they must hold the part firmly and make good electrical contact. Because the possibility of buffing before chromium plating has been ruled out, great care is needed to maintain a uniformly high standard of performance by all baths used in the plating sequence. Special precautions must be taken to prevent contamination of other baths with chromic acid.

We are now operating seven fully automatic plating machines as well as a few still tank sequences in this manner for steel parts, copper plated and buffed steel parts, brass parts, and zinc alloy parts. Often parts of more than one base metal are nickel and chromium plated through the same machine. On the whole the results obtained have been satisfactory, but we do not yet feel that we have solutions to all problems which arise. The remarks which follow should be regarded as a progress report.

Racks

It is hard to overestimate the importance of good plating racks; the need is fundamental. While it is deceivingly simple to bend a hook or twist a wire which will serve to suspend the piece to be plated from the cathode bar, efficient and effective and durable racks require thoughtful designing and careful building. They deserve the dignity and importance associated with the word "fixture."

Since chromium plating requires higher current densities than can at present be effectively used in either copper or nickel plating and since the effect of poor current distribution is so much more noticeable in chromium plating, racks used for both nickel plating and chromium plating are designed primarily for the chromium plating operation.

The current carrying capacity of the racks must be adequate to handle chromium plating needs. Parts to be plated must be held firmly and ... rack within the dimensional limits impose... available equipment so that solutions drain w...

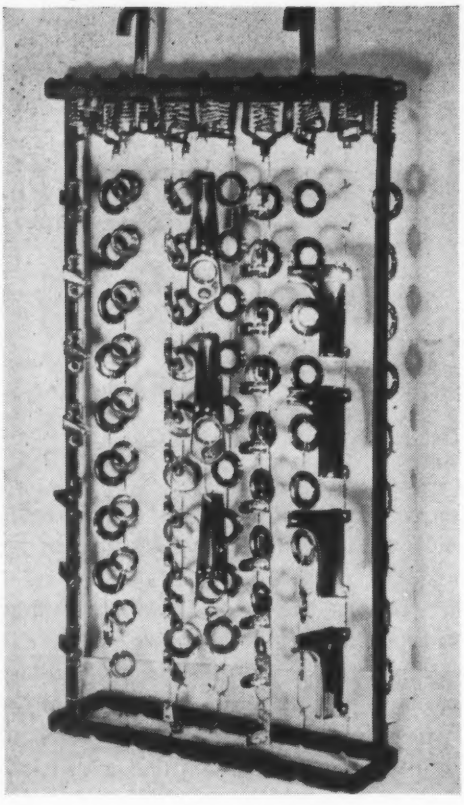


Fig. 1. Loaded chain type rack

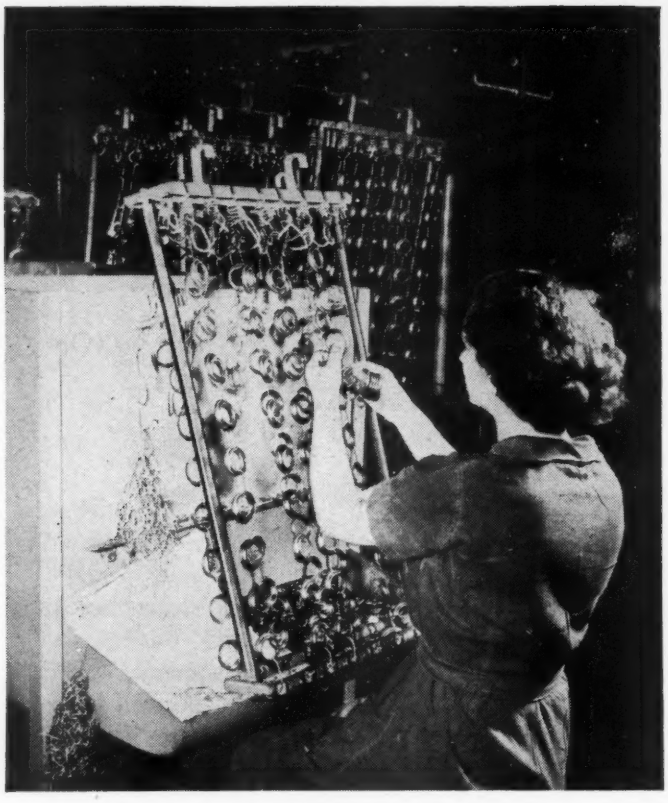


Fig. 2. Loading of the chain type rack

the loaded rack is lifted from them, the predetermined surface area to be plated is provided, and a minimum amount of guarding or shielding is required to prevent burning. Wherever possible, parts should be arranged so that they shield other pieces, both those on the same rack and those on adjoining racks in the plating solution. At the same time they must not be permitted to shield each other too much; the penalty in this case is inadequate chromium coverage as well as poor nickel plate distribution.

In this connection it is well to keep in mind the fact the hydrogen gas produced in cavities or at holes during chromium plating may cause mischroming if allowed to move upwards over a significant surface.

The racking and unracking effort required should be minimized both to hold down cost and to prevent as much as possible the occurrence of scratches, nicks and dings which necessitate stripping and refinishing.

For economy of operation, both with respect to current consumption and rack life, a good rack covering is necessary. In addition, a good rack covering is frequently essential to the quality of the finished piece. Unfortunately, there is not availableany wholly satisfactory rack insulating material. Rubber coatings, wrapped-on insulating tapes, and a variety of lacquers or synthetics which are applied by repeated dipping and drying or by repeated brushing and drying have been tried, with varying degrees of success. At present we are most contented with a vinyl base synthetic material which is applied by dipping. Coated racks must not contaminate any of the solutions used, nor should they suffer too rapid deterioration in service when not subjected to abuse in handling. Racks with blistered, cracked, or loose insulation should be repaired promptly since such racks are very likely to carry chromium plating solution into the cleaner and sometimes as far as the nickel solution.

Even when the racks are in good repair, it is desirable to remove all chromic acid and deposited chromium from them by careful rinsing followed by a two-minute anodic treatment in a 3- to 6-ounce per gallon solution of sodium carbonate before they are used again.

Fig. 1 illustrates what we call a chain-type rack. It is particularly useful for nickel and chromium plating small parts when a variety of different parts must be handled. Parts to be plated are linked together by "C" hooks with electrical contact established for the chain thus produced through both the bottom and top links. Good contact is assured because the chain is held taut by the pull exerted by the springs at the top of the rack. One spring, which is located so as to be above plating solution level, is provided for each chain of work. It is easy to load with a predetermined number of square feet even though the size of the different parts varies. The "C" hooks build up with plate after about five cycles and are then discarded or stripped. Aside from this, the rack is rugged and maintenance

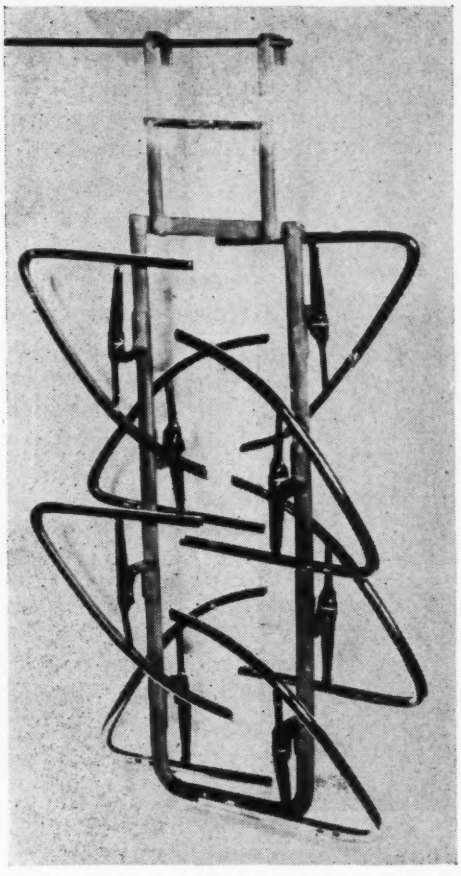


Fig. 3. Loaded glass channel rack

Fig. 4. Loading of the glass channel rack

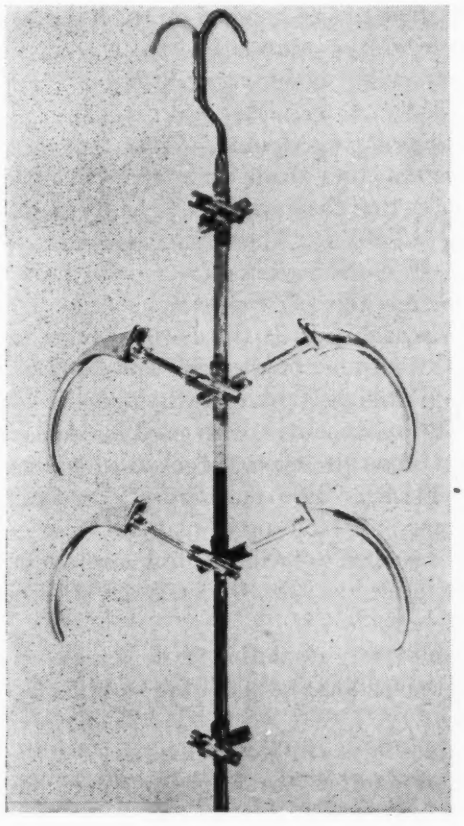


Fig. 5. Rack for outside door handles

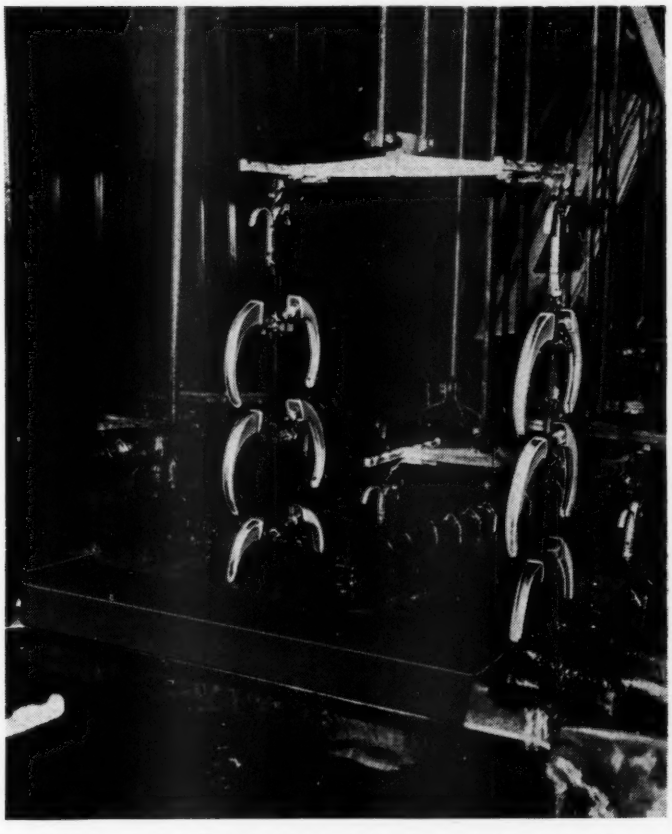


Fig. 6. Outside door handle racks in plating machine

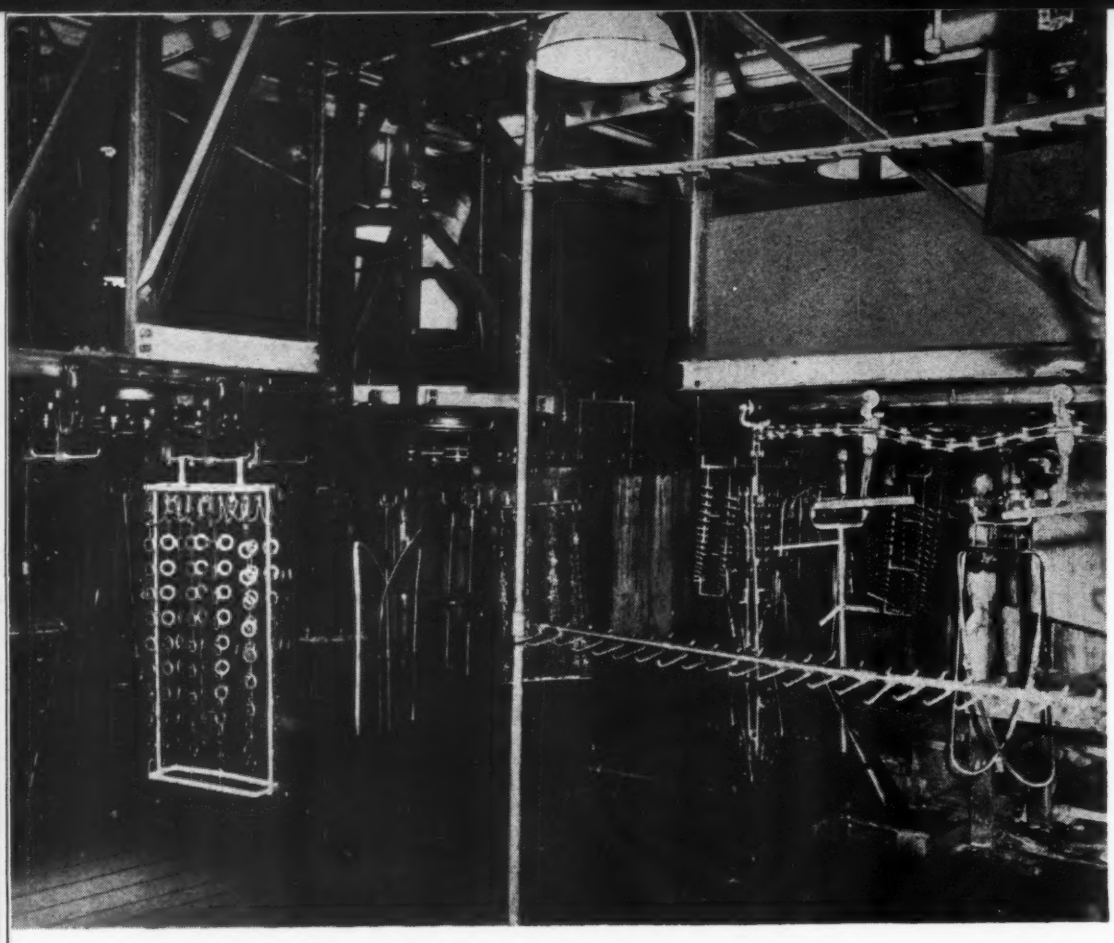


Fig. 7. General view of a variety of racks carried on monorails

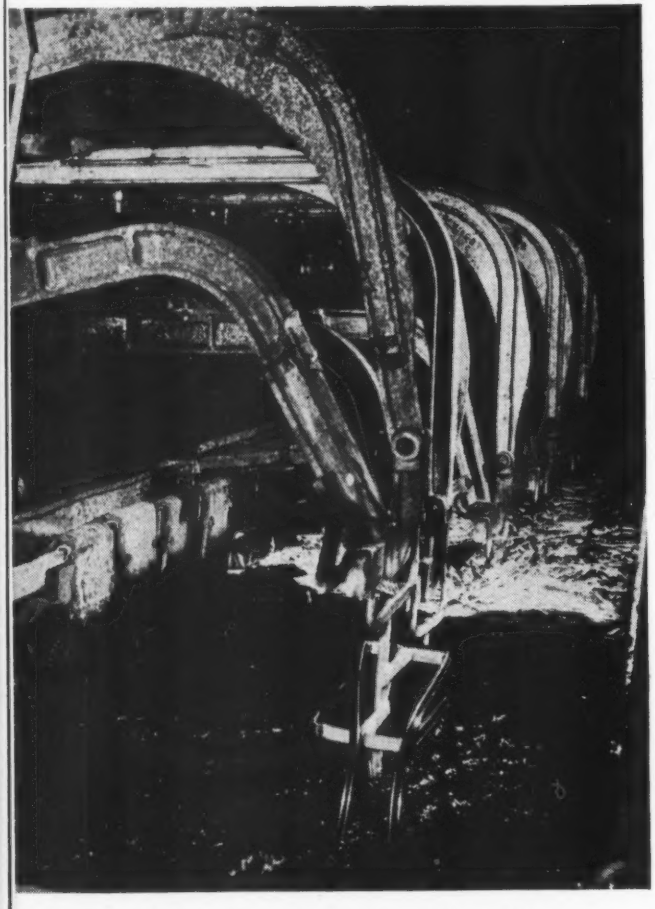


Fig. 8. Polystyrene spray suppressing chips on top of chromium solution

cost is low. It is not customary to place different kinds of parts on the same rack as is shown in Fig. 1. Our purpose in preparing this illustration was to convey an idea of the variety of work that can be handled on this type of rack.

The racking operation shown in Fig. 2 is fast with practice; the unracking operation is still faster. In Fig. 3 is shown a loaded rack for nickel and chromium plating controlled ventilation glass channels. Note that the parts are staggered so that they shade each other but little and yet are arranged so that the ends are sufficiently guarded to prevent treeing or burning. The racking operation shown in Fig. 4 is simple, but the grip on the piece is firm. The operator places the top of the straight brass holding spring in the channel, pushes the lower portion of the channel toward the frame of the rack and, at the same time, rotates the part slightly to engage the lower end of the holding clip. The movements are reversed for unloading.

Figs. 5 and 6 show the type of rack used for outside door handles. The holding socket serves a dual purpose in that it also prevents build-up of plate on the steel insert. The socket is open to facilitate drainage. Note that the handles are placed so that the ends are shielded by adjacent pieces.

Fig. 7 shows a variety of plating racks being conveyed by monorail to the loading station of the plating machine.

Chromic Acid Contamination

It is generally recognized that the presence of chromates, even in low concentrations, cause trouble in solutions used in plating. In cleaners and acid dips, they may cause

non-adhesion of subsequent plate, in cyanide plating solutions they may cause the deposit to blister and, in addition, greatly reduce cathode efficiency. In acid solutions, contamination with chromates may result in brittleness and lowered adhesion, discoloration and loss of efficency. A drop of water yellowed with chromic acid which falls on a part to be plated, even though it falls before the part has been cleaned electrolytically, will usually cause peeling or blistering of nickel deposited over the area it wets.

In addition to the rack treatment referred to previously, it is desirable to rinse thoroughly the conveyor carriers to rid them also of chromic acid.

The chromium solution ventilation system should be used only for chromium solutions. Its ducts should not cross over other plating tanks in the sequence or over work to be plated. If this is unavoidable, then guard pans are desirable to catch any drippage which may occur. Storage tanks, pumps, heat exchangers, and pipe lines used for chromium solutions should not be used for the handling of other plating solutions.

If the ventilation system serving the chromium solution is somewhat inadequate, some of the spray from the chromium plating operation may drift through the air and fall into other solutions. The use of polystyrene spray suppressor chips now available are of value in holding down chromic acid spray (Fig. 8). Unfortunately no suitable means has been developed as yet, to our knowledge, to keep them in place on the surface of a solution in an automatic machine; racks traveling through the tank push the chips to its delivery end and lift them out at too rapid a rate. A way to overcome this difficulty is needed. It should also be noted that a much used chromium solution may overheat when covered with a blanket of spray suppressor chips because the heat loss from the solution surface is reduced. Other plastic materials have been found suitable but are not available at present.

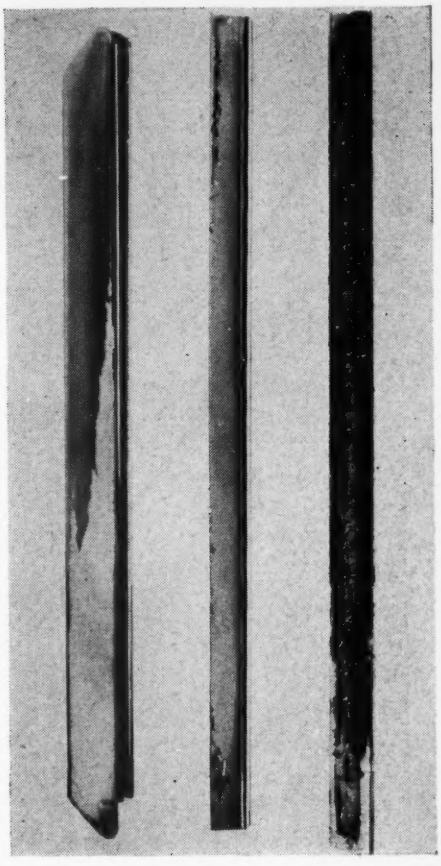


Fig. 9. Defects in nickel-chromium coatings. (a) Dull chromium, (b) and (c) double plate in nickel

Defects

Even assuming that the nickel solution used in the sequence is maintained at desired concentrations, that organic impurities are properly and regularly removed by treatment with activated carbon, and that metallic impurities are held within tolerance limits by low current density dummying or by chemical lime and nickel carbonate treatment at an elevated *p*H or by other chemical treatment, losses may occur due to (1) roughness, (2) staining, (3) peeling, or (4) irregular mischroming.

(1) *Roughness*

Roughness is usually caused by small solid particles which settle on the work during plating. Light roughness, though not to be desired, may be unimportant if the parts are to be nickel buffed before chromium plating, but when chromium is deposited immediately after nickel plating, the expected saving may be lost due to the cost of corrective operations necessary to remove roughness. No easy way to eliminate roughness is available. Continuous filtration is necessary; the rate of filtration should be such

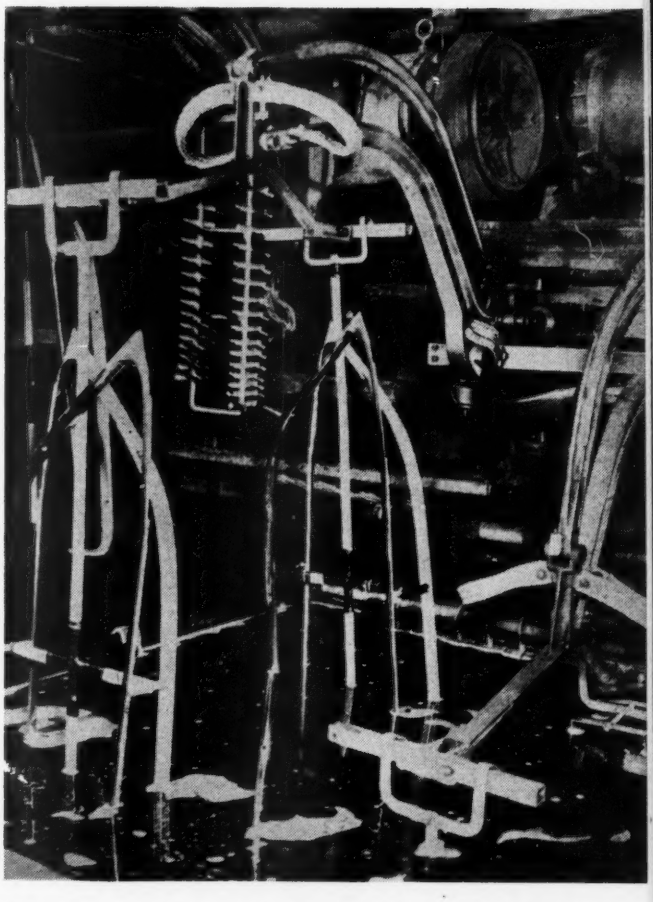


Fig. 10. Spring loaded cathode shoe on full automatic

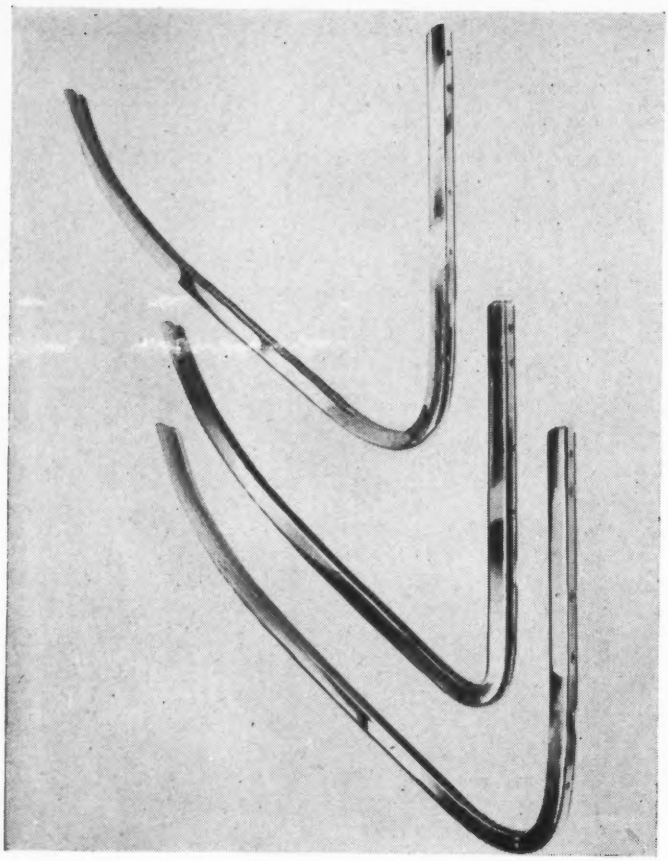
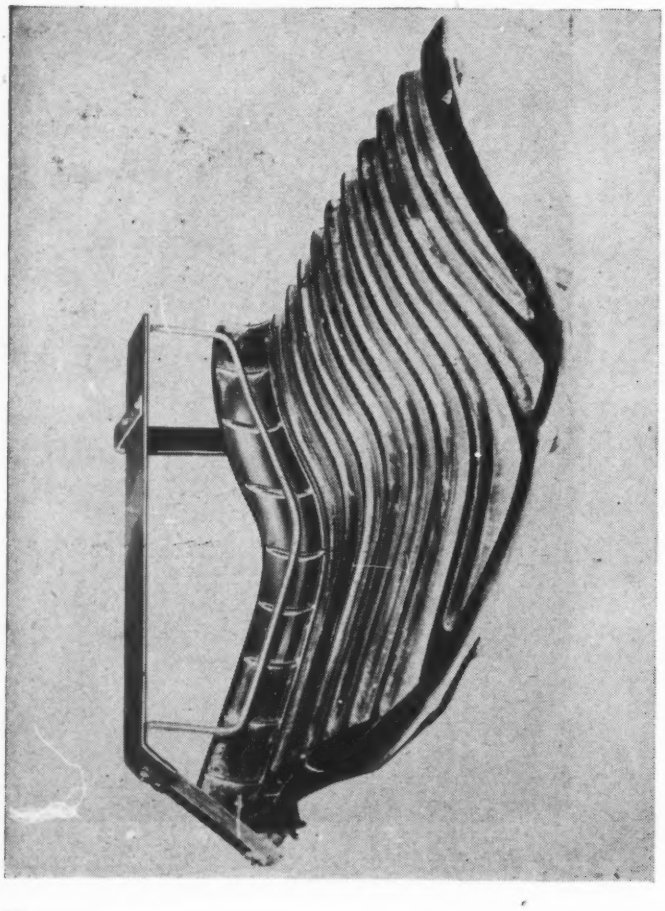


Fig. 11. Peeling due to stray current



that a volume equal to that of the plating solution be handled about every three hours. It is desirable to supplement continuous filtration with regularly scheduled complete filtrations. This may be accomplished during down time by diverting the return of the filtered solution to a storage tank until the plating tank has been emptied. After the bottom debris has been removed, the solution may be returned to the plating tank also through the filter. Complete filtration may be necessary each week, but once a month is usually adequate.

Great care must be exercised to prevent filter aid and activated carbon from entering the bath. It is our practice to place filter paper over the filter cloth, not only to make cleaning easier but also to guard further against introduction of foreign material into the plating solution.

We omit anode bags in some installations where carbon-type nickel anodes, rolled or cast, are used. If the anode to cathode distance is less than it should be and if the work being plated may catch and tear the anode bags, then, assuming good filtration, it may well be better not to use bags.

(2) *Staining*

We refer to irregular areas of dull nickel on an otherwise bright plated piece as stains. In general, the cause of this trouble lies in the cleaning sequence. A discoloration due to overcleaning or cleaning in a contaminated cleaning solution or too long exposure to air after removal from the cleaner will result in stained nickel. It is our present feeling that the accumulation of buffing compound which is found on pieces, particularly after automatic buffing, should be removed by means of a cleaning action which has no chemical effect on the base metal. A degreasing operation will do this, although solid dirt which may remain on the buffed surface after degreasing is difficult to remove in electric cleaners. Spray washing by means of a mild alkaline solution such as one or two ounces of trisodium phosphate or sodium metasilicate may serve this purpose as may soaking and spraying with proprietary solvent emulsion solutions. Assuming that most of the solid dirt has been removed by means of one of the methods mentioned, then a brief direct electro cleaning may be used, but in any case it is felt that it is desirable to finish the cleaning in a reverse electrocleaner. Most tarnish or deposit from a direct electrocleaner will be removed in the reverse electrocleaner. The rinsing after cleaning should be thorough and should preferably start before the parts removed from the cleaner have an opportunity to dry. A number of different

Fig. 12. Intermediate electrode for deposition in recess. Cathodic collector plate at left, conforming nicke iwire anode at right

cleaners have been used successfully. It is desirable, however, to select one with a reasonably high tolerance for chromic acid contamination since, in spite of all precautions, some chromic acid does get into the cleaners. The surface to be plated, whether it be brass, copper plated steel with exposed base metal, or zinc alloy, should be not more than slightly etched.

A mild sulfuric acid or hydrochloric acid dip (1 per cent to 4 per cent, should be used after rinsing to neutralize residual alkali and to remove light surface films. The acid dip is considered to be an essential step in the cleaning procedure.

There is, it is felt, considerable room for improvement in the cleaning prior to nickel and chromium plating. Losses due to staining are recurring and sometimes difficult to remedy.

The use of a cyanide copper strike following alkaline cleaning and acid dipping is, of course, necessary when zinc base alloy parts are being plated. When other metals are being plated, the use of a copper strike is frequently helpful in reducing losses due to staining, but the gain may be easily offset by other hazards introduced: another deposit which may peel is brought in, and a dull copper strike may diminish the brilliance of the finished piece. All things considered, however, it is felt at present that a strike deposit of copper not exceeding 0.0001 inch in thickness is helpful. When better cleaning methods are known, it is expected that the use of this plater's crutch for materials other than zinc alloy will be discontinued.

The composition and operating conditions of the copper strike is as follows:

Copper cyanide	2.5 oz/gal
Sodium cyanide	1.0 oz/gal
Rochelle salts	6 oz/gal
Sodium carbonate	2 oz/gal
Sodium hydroxide	1 oz/gal
Temperature	110° F
Current density	20 asf or less

Metallic impurities are held at a minimum by regular, small additions of sodium hydrosulfite.

When a copper strike is used, it must be followed by a good water rinse operation, by another acid dip similar to the one described above, and perhaps by another water rinse before the parts are ready for nickel plating.

(3) *Double Plate*

Double plate is a term which we use to describe a peeling of a layer of nickel from an underlying layer of nickel (Fig. 9b and c). In other words, the nickel plate has split. This is due to an interruption or fluctuation in the current during the nickel plating operation and can be eliminated only by steps which assure that the current flow during the plating operation is continuous and reasonably uniform. Fluctuations or breaks in current flow may be measured by means of a properly placed tong ammeter or, more simply though only qualitatively, by attaching one lead of an ordinary flashlight bulb to the work carrier and the other, by means of a trailing wire or rod, to the solution. Variation in the brightness of the filament as the carrier travels through the plating bath indicates a variation in current flow through the plating rack. The light, of course, goes out when current flow is interrupted. Either method may be used without disturbing normal handling of work being plated.

It seems that bright nickel plating solutions suffer more from this type of trouble when impurities are present.

Chromium plating will usually cause double plate to become apparent, but not always. In some cases, plate failure due to this condition develops only some time after the part has been in service.

(4) *Stray Current Effects*

Mischroming, poor color, peeling, and other plating defects may result from stray currents. By stray current is meant that portion of the current which does not flow from the anodes through the solution to the work being plated as planned but which instead follows an unintended path of lower resistance. Everyone has observed at some time a steel tank used for cyanide copper plating which had acquired a copper deposit on the portion adjacent to the anodes. This deposit of copper was the result of a stray current. Because the anodes were close to the side of the tank and because the work being plated hung close to the bottom of the tank, a portion of the current had been diverted through the low resistance path from anode to tank side to tank bottom and so to the work; the portion of the tank behind the anode had become cathodic, and copper had been deposited; the portion of the tank bottom under the work correspondingly had become anodic.

Similarly work being transferred into a nickel or a chromium plating solution may, before cathodic contact is established, become part of a stray current circuit. If this happens, a portion of the piece becomes anodic for a short time—long enough to cause trouble.

It is thought good practice to provide means for making work cathodic as it enters the nickel and the chromium solutions. The method by which this purpose is accomplished varies depending upon the type of equipment in use. Fig. 10 illustrates a spring loaded cathode contact on a Stevens side-arm machine.

In Fig. 11 are shown three pieces of glass channel which were deliberately subjected to stray current by insulating the plating rack. Note that nickel has deposited on some portions of the parts. Close examination reveals that some corrosion has oc-

(Continued on page 95)

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THIS ARTICLE:

. . . is a resume of the steps which the author feels are needed to increase the rate of polishing in Australia. It is hoped to be of interest also to our readers in the U. S. and other countries. Comments are invited.

METAL POLISHING

E. J. WRIGHT

Lidcombe, New South Wales, Australia

AS ONE WHO HAS SPENT a lifetime in the metal finishing industry and who has seen the electroplating side of the business develop from the secret-formula stage to a stage where analytical control of plating solutions is a regular procedure, I am much disappointed in the slight progress that has been made in metal polishing during the past thirty years, at least in Australia.

Polishing accounts for a large part of the cost of the finished article. If the Australian electroplater is to compete with non-plated finishes such as synthetic and porcelain enamels and, further, if he is to compete in the world markets, it will be necessary to bring Australian polishing methods up-to-date, to make the wheel fit the work, and the machine fit the wheel. This means that the tapered spindle machine should be replaced by the one with a straight spindle with a square. Whenever the latter machine is mentioned in Australia, the question is immediately asked, "What about the extra time required for changing wheels?" The answer lies in the wider-faced wheel of larger diameter which can be used on the straight spindle: it is just as easy to polish a ½-inch wide piece on a wheel with a 4-inch face as on one with a 2-inch face, provided, of course, that the polisher works all over the face of the wheel; a 3 or 4 inches wide piece can be polished with one pass down the wheel. Hence, while it may take a little longer to change wheels on a straight spindle machine, the longer life and greater efficiency of the larger wheel more than makes up for the difference.

In view of the present shortage of polishers it is imperative that the utmost should be obtained from those available.

One word in season as to the Australian polisher: I have seen polishers in various parts of the world and must say that, given proper facilities, the Australian polisher can more than hold his own with the best of them.

Since it will not be possible to deal here with all the ramifications of metal polishing, I will confine myself to questions of supplies.

Polishing Wheels

Sewn buff wheels can be made from either spirally, circularly or diagonally sewn buff sections. Their flexibility can be controlled by varying the width of the sections, say 3/16 inch for a hard wheel to ⅜ inch for a more flexible wheel; the spacing of the sewing also has some bearing on the flexibility of the wheel. These wheels can be built up to any width by using sufficient number of sections. Because all wheels should be bushed with a metal bush before use, the hole in the sections should be smaller than the outside diameter of the bush to be employed.

Before being glued together, the buff sections should be balanced on a mandrel to make them run as true as possible. Mark each section at the balancing point and, when glueing, lay each balancing mark at a right angle to the preceding one. In making a wheel, use a mandrel threaded on both ends and of the same size as the spindle for which the wheel is intended, two pieces of ¼ or ⅜ inch plate of slightly larger diameter than the buff sections and drilled in their centers to take the mandrel (thick plywood with suitable washers is satisfactory if steel plate is not available), and two nuts for the threaded mandrel.

Place the mandrel in a vise and hold it by the bottom nut, next place the bottom clamping plate and one buff section over the mandrel. Have ready one or

two pots of good thick glue, two if the wheel is to be very wide; the pots are to be used alternately to prevent jelling of the glue during use.

Coat the top side of the first section and the under side of the second section and bring them together, pressing firmly; repeat until the required number of sections have been glued together, taking care not to glue the top side of the last section. Put on the top clamping plate and tighten the assembly by means of the second nut on the top end of the mandrel. Leave at room temperature for at least forty-eight hours.

Remove the nuts and the clamping plates and balance the wheel while still on the mandrel by nailing a piece of lead on the light side. Now put the wheel on the spindle and true up. Size the wheel by applying a coat of thin glue and letting it dry for three or four hours, or by coating the wheel with thin glue while still on the spindle, letting stand for three or four minutes and then starting the spindle and allowing it to run for about five minutes at which time the loose threads are rubbed down with a piece of lump pumice or soft brick.

The wheel is now ready for a coat of emery. Apply a second coat of glue and roll in emery, dry for four to five hours, apply a third coat of glue and a second coat of emery and allow to dry. Before using the wheel, tap its face lightly; this gives a softer face.

Wheels of sewn buffs which have been properly made and which are steamed for removal of old abrasives will last for over twenty years with little noticeable wear when used as roughing wheels and, of course, proportionately less when used as grease wheels.

Sewn canvas wheels are of similar construction. They are heavy duty wheels, useful where it is necessary to employ coarser grain abrasive.

The rise canvas wheel is another heavy duty wheel. It can be made harder or softer depending on the distance from the periphery that the discs are glued.

Felt wheels should only be used as finishing wheels or at least with abrasives of 150 grit or finer. They are now being made in Australia to any width and any diameter.

The wood bob, as it is called in England, or the *block wheel*, as it is known in America, can be made in the polishing shop, but since it can be very dangerous if not properly made, great care should be exercised in its construction. This wheel is used in small arms factories almost exclusively and has many uses in the polishing of parts with sharp edges or bevels that must be maintained; it requires polishers of more than the average skill.

Block wheels can be covered with felt, bull neck or walrus leather. For the centers, some of the thick plywoods that are available should be quite satisfactory. The wheels can be made as follows: To make the center, glue sufficient plywood together for the width of the wheel, bush and true up. If possible the center should be in one piece; it is unwise to use more pieces unless one can be sure that all are of exactly the same texture; the wheel will never run true if the pieces differ in texture.

The nails used in securing the cover are specially made for the purpose and are called bob tacks in England; they are not readily available in Australia. If ordinary nails are used, they should be ground to a slow taper so that after the wheel is dried, they can be withdrawn without fracturing the bond between the wood and the covering.

To cover the wood center after it has been trued up proceed as follows: Place the center in a five-inch vise and tighten the vise as much as possible without damaging the wood; after squaring off one end of the cover, place it on the center, drive two or three nails barely through, remove cover and nails, and apply glue to both center and cover for a distance of about 2 inches. Place the nail holes in the cover over the nail holes previously made in the center and drive home the nails leaving about half to three-quarters of an inch sticking out to facilitate withdrawal. Now alter the position of the center in the vise, allowing about 6 to 8 inches according to the diameter of the wheel for the next lot of nails; drive the nails barely through the cover, remove and glue as before, stretch the cover and drive home the nails. If the wheel is more than 2 inches wide, it is better to make this a two-man job with one doing the stretching and one driving the nails. Continue until within about 4 inches from the starting point, cut off any large surplus of the cover, drive nails as before, stretch as far as possible, mark and cut off, glue the remaining 4 inches, and, using an old file or the like behind the nail, bring the ends together, and have someone drive the last nails home.

When the wheel has dried (after at least 48 hours), grip the heads of the nails in the vise and turn them a couple of times; the nails will come out without hurting the joint between the center and the cover. The wheel is now ready for trueing and setting up as described before.

Compress wheels are not obtainable in Australia and can hardly be made in the shop. They are very good wheels for general use as the face can be formed to suit any irregularly shaped work. They are made from sections of felt, canvas or leather, which are placed at right angles to the direction of rotation. They can be obtained in various densities: hard, medium or soft.

The sheep skin or basil wheel is another wheel which is not used much in Australia although plenty of basils are available. The flexibility of these wheels can be controlled by sewing varying number of basils together and finally stitching all together with very wide stitches.

Walrus wheels made from walrus leather are excellent for roughing brass or aluminum parts with greaseless compound. They are also good for jewelry and for general polishing of small parts. Walrus leather is the best medium known to the polishing trade for holding the abrasive.

Balancing

Polishing wheels should always be in balance so as to avoid bumping which in the case of a fairly hard wheel produces chatter or wheel hammer marks on the work. These are exceedingly difficult to remove in the succeeding operations. The wheel should always be run in the same direction; this can be accomplished by painting the right hand side and keeping the painted side to the right whether the wheel is on the left hand or the right hand end of the spindle.

Speed of Polishing Wheel

The average speed of polishing wheels is approximately 7,000 surface feet per minute for all metals except aluminum die castings which require approximately 8,500 surface feet per minute.

Polishing Glue

The polishing wheel, being the polishers' tool of trade, requires the most efficient medium for bonding of the abrasive.

Only high-grade animal hide glue should be used for dressing polishing wheels. In America glues are made especially for this purpose, but these are unobtainable in Australia for various reasons. A glue manufactured in Australia which closely approximates these special glues is known as Binter's Roller No. 2 Pearls. Bone glue is unsatisfactory for polishing. It is most important that the glue be stored in a cool, dry place. When kept under these conditions, it will retain its quality for years.

Only sufficient glue should be prepared for one day's work. When the amount has been determined, it should be weighed carefully and placed in the designated containers; these should be kept scrupulously clean.

The following table shows the percentages of glue and water which should be mixed when the glue named above is employed. The percentages can be varied to suit any glue on hand, but once figures have been obtained for any particular brand, they should be rigidly adhered to.

Abrasive Size	Per cent Glue	Per cent Water
36	50	50
46	45	55
60	40	60
80	35	65
100–120	33	67
150–180	30	70

The glue should be poured into clear cold water; the colder the water, the faster and the greater the swelling. Ground glue should be soaked for at least 1½ hours, pearl or flake glue for 4 to 6 hours, and cake glue for at least 10 hours and preferably overnight.

At the completion of the soaking, the glue is transferred to a water-jacketed glue kettle. Its temperature should not exceed 140° F because overheating results in loss of strength: glue heated to 200° F or higher loses about 50 per cent of its strength; the same applies to glue which has been subjected to prolonged cooking. It is therefore advisable that at the end of each day all unused glue be disposed of and the pots and the kettle be thoroughly cleaned and disinfected.

A separate pot and grush should be kept for each grade of glue and abrasive to prevent contamination with oversized abrasive. Thus four grades of abrasive require four separate pots and brushes.

The abrasive grain should be kept at a temperature of from 100° to 120° F, and the wheels should be heated to the same temperature to prevent them from chilling the glue while they are being rolled in the abrasive.

Those who have done any metal polishing have probably noticed that where a wheel has been hanging on the rack for some time during the dry summer months, the abrasive flies off on use and the wheel becomes useless in a very short time; this condition also obtains in the winter in America where the factories are steam heated; it is caused by the wheel being too dry. Animal hide glue has the property of giving off and taking on moisture depending on the humidity. The fact that hide glue reaches its maximum strength when it contains 10 to 12 per cent of moisture explains the necessity for what we shall probably not see in Australia for some time, the polishing room foreman's dream. I refer to the *set-up room* used on the other side, a room for dressing polishing wheels which is free from drafts and in which the temperature and humidity are controlled within close limits. Ideal drying conditions are 45 per cent relative humidity at 75° F or 55 per cent relative humidity at 90° F.

To ascertain whether a wheel is dry or not, hit it with a round steel bar and observe how readily it cracks: if not dry, it will not crack; if too dry, it will splinter and crack and the abrasive will fall away.

The round steel bar and not the end of the spanner should also be used to crack the abrasive coating preparatory to its use.

Abrasives

All grain sizes mentioned here are according to the American standard. Abrasives are imported into Australia from various parts of the world, but no two

(*Continued on page 98*)

good judgment

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IN BRIEF:

A SEARCH REVEALED several hundred patent references on electroforming. In these references, attention was given to nearly one hundred different industrial products of economic importance. The information disclosed therein, together with additional accounts in technical journals, is used as a basis for describing the status of electroforming, for outlining significant advantages of the electroforming process, and for reviewing methods and procedures practiced by electroformers.

A new process for the continuous automatic production of fountain pen caps reveals interesting possibilities for low-cost mass production of other consumer's goods. The results of a pilot-plant development are described to supplement the data gathered from the literature.

ELECTROFORMING—A LITERATURE REVIEW AND A NEW APPLICATION

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Introduction

SEVERAL RECENT and valuable contributions to the technical literature have revealed new electroforming developments and others disclosed new methods and techniques, but in none of them was the industrial status of electroforming defined nor was the literature surveyed with the view of documenting methods. This paper is an attempt to fill this need and to acquaint electroplaters with the special devices and techniques practiced by electroformers.

A literature survey revealed that electroforming is considered an economic manufacturing method for an impressively large number of articles representing widely diversified shapes. Complete details of the procedures are not usually disclosed, but essential information is given in many different publications and especially in the patent literature. The results of this survey also indicated a recent tendency among investigators to publish limited information in technical papers in place of more complete data necessary for patent disclosures. The number of patent applications which reached its peak in the period 1929 to 1932 has steadily fallen off since that time. However, the number of technical papers published in the last two years is considerably greater than that in any equivalent period before the war.

Industrial Importance of Electroforming

Products made in whole or in part by electroforming are supplied to many large industries. Automobile, aircraft, radio, radar, glass, printing, rubber tire, steel, and munition industries are among these. Several hundred plants are known to be producing regularly scheduled electroforms, valued at more than one hundred million dollars per year.

Radar is the youngest of these industries. Several recent publications discuss electroformed radar parts produced in large volume during the war. Electroforming is said to be unequaled as a precision method for making electronic cavities[33]*, and costs are less than machining cost would be[3]. Procedures for forming radar tubing and antenna housing from iron[34, 5, 6],

*For illustrative purposes, selected references from the bibliography are shown in footnotes.

silver and copper[3, 33], are outlined. The manufacture of dial faces is an accomplishment of an earlier origin[4].

Wear-resistant dies and molds, electroformed to reproduce accurately fine detail, are made for molding of glass, plastics, and metals. It has been claimed that the Ekko process developed for electroforming rubber tire molds has found application in the glass sound record[26] and plastic industries[30]. Nickel-alloy molds for die casting and injection molding of plastics are reported to result in savings of at least 25 per cent[27].

Procedures for electroforming metal stamping and wire drawing dies are given in patent disclosures. After the forming, these parts are usually chromium plated for better wear resistance.

Foundries employ electroformed pattern molds. A method is reported for producing them from original wood or metal patterns, and the advantages of the electroforming method are outlined[29]: accuracy and uniformity unequaled by other processes and lower costs.

Electrotypes are the oldest known kind of electroformed article. Jacobi, who developed a process for printing Russian bank notes in 1839, is credited with their origin. The first publication was a British patent granted in 1840*, and the first U. S. patent was released five years later†. Since that time, more than 350 U. S. patents are recognized as relating to electrotypes, a number that exceeds the number of references to any other kind of electroform. Many technical publications described advances in this field. Chief among these are those prepared by National Bureau of Standards investigators[9,11,13,15,19] and released by Printing Plates Research, Inc.[21,22] Summaries of electrotyping practices have been published at various times[10,14], but the most recent developments in molding materials and deposition techniques are to be found in the patents. Of special interest among these is a recent patent disclosure of a vinyl acetate-vinyl chloride molding composition as a basis for copper electrotypes‡. The industry is currently engaged in evaluating new baths and methods of agitation for their efficacy in producing hard, wear-resistant electrotypes with very fast deposition rates. The copper sulfate-sulfuric acid bath has been used for the past one hundred years and is still the most important. Improvements can be expected from investigations of fluoborate and alkane sulfonate baths.

The industrial importance of production of stampers for recordings is nearly as great as that of electrotypes, and its history of development is similar. Much of the know-how related to manufacturing sound records was originated by Thomas A. Edison, who was granted several patents relating to the deposition of conducting surfaces on wax originals§; his methods included the precipitation of metal vapors in vacuum or by silent discharge. Cathode sputtering, chemical reduction of silver salts, and methods of applying metal powders or metallic paints and graphite are referred to by other patentees. Some modern techniques are summarized in recent technical papers[8,24].

Reflectors are another example of mass-produced electroformed articles. Accurate optical reflection is secured by pre-designed contours faithfully reproduced by electroforms[26]. A final rhodium plate is applied to secure permanence of reflectivity[35].

Band instrument manufacture was revolutionized as a result of a determined and successful research program which presages similar long-range improvements in the manufacture of other products. An account of the program and procedures for mass production has been reported by Savage[1,2]. It is said that better quality instruments are made at less cost by electroforming.

Electroformed sheet, strip, screen, tubing, and wire are produced on a large-volume basis. The historical significance of iron and copper tubing manufacture begins with the names of Cowper-Cowles[38], Guillet[47], and Elmore[46], whose reports were supplemented by others[41,44,49]. Rolling or tumbling finished tubes to effect their removal from the starting forms is described in more recent papers[45,49]. Modern techniques are similar to those applied to radar tubing, mentioned previously.

Cowper-Cowles is also known for a forming process for sheet from iron[38,41]. Another process is the Anaconda copper electro-sheet development[40,42] in which solution from the refinery was circulated to the electroforming cells and returned therefrom for replenishment; continuous copper strip was formed in these cells and sold to manufacturers for further fabrication. Another manufacturer produced laminated copper-and-nickel strip, subsequently drawn into shapes such as saucepans[4].

Screen, used for carburetor strainers, filters, radio speakers, etc , is electroformed from nickel[36]. It has been stated that electroformed nickel screen is used in producing atomic bombs‖. Copper screen is mentioned in a paper describing some new electroforming procedures[37].

Also produced by electroforming in significant volumes are heat exchangers[8,5], floats[8,25], pitot-static tubes for measuring air flows encountered by moving aircraft[5,33], rolls¶, seamless tanks[8], and gears[6].

The literature includes other articles such as deto-

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* British Patent 8610. † U. S. Patent 4130. ‡ U. S. Patent 2,400,518. § U. S. Patents 484,582, 657,527, 680,520, and 713,863. ‖ Blum, "Military Applications of Electroplating in World War II", Am. Electrochem Soc., Preprint 90–32. ¶ Stoddard, in an address before the Dayton Branch, Am. Electroplaters' Soc., February 15, 1947.

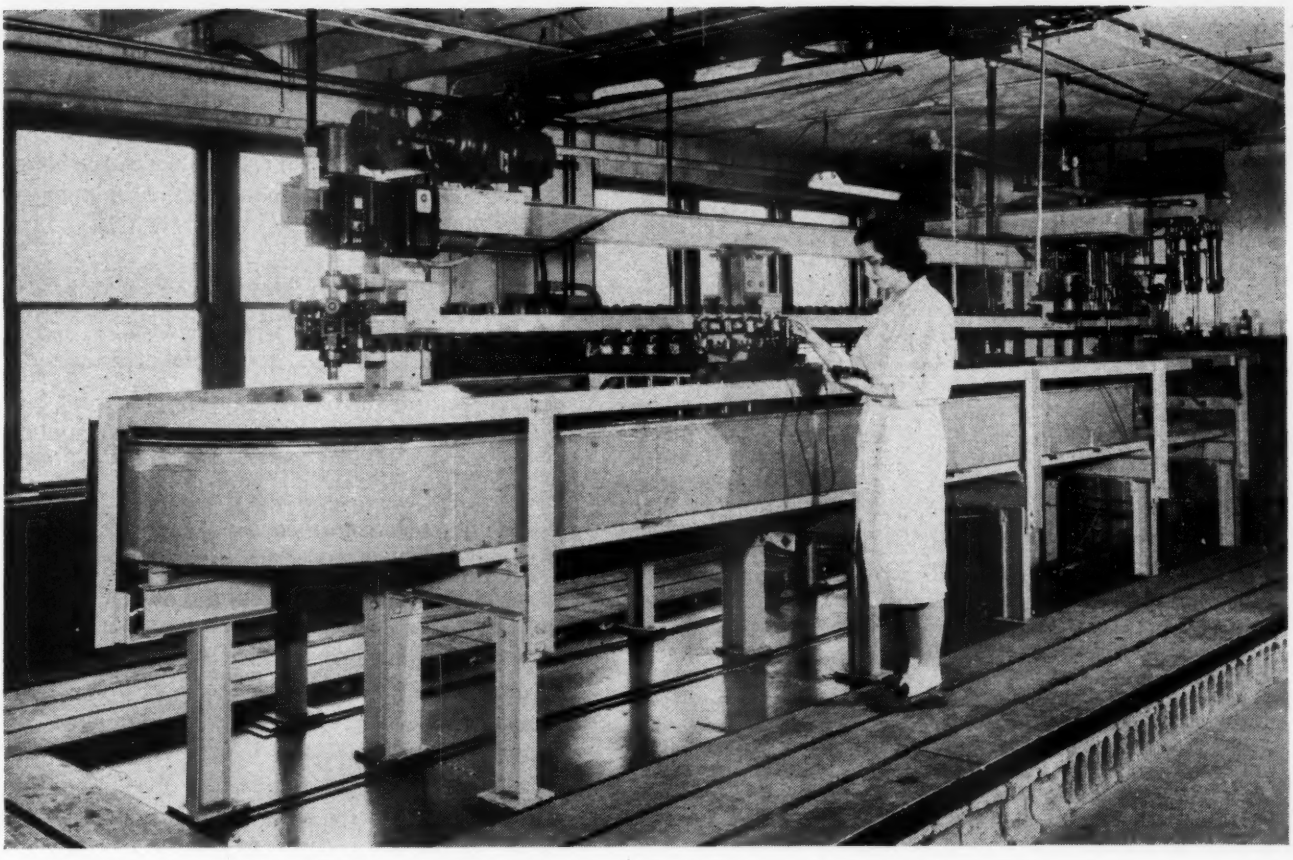

Fig. 1. View of pilot plant for electroforming fountain pen caps

nator tubes, distilling flasks, foil, jewelry, ornamental replicas, manifolds, marking tools, paint spray masks, pipe couplings, needles, gaskets, rings, blast furnace tuyeres, venturi nozzles, stencils, webbing, flexible bellows, and welding tips. Many of these are believed to be produced on a small-volume basis.

From the above account it is understandable that we may live and work with many articles directly produced by electroforming. It may be surprising to some to learn that we can be buried in one; procedures for electroforming caskets are patented, and their manufacture is known to be carried out on a limited but continuous scale.

Fields of Potential Application

Some of the articles produced today by electroforming cannot be produced by other methods. Others are reproduced in large numbers with greater accuracy than afforded by casting, stamping, etc., and, for these functional reasons, are made by metal deposition. Frequently it is found that shapes that are stamped or otherwise formed from steel, copper, brass, zinc, or aluminum can be electroformed from a better material, not easily worked by ordinary forming methods. This is especially true of the precious metals and of nickel and cobalt and their alloys. Some day it will be true of alloys of refractory metals: tungsten, chromium, zirconium, titanium, etc.

Most electroforms are so produced because they can be made with an equivalent or better quality at lower cost. Electrodeposition and stripping procedures are readily adaptable to continuous and automatic processes, involving little, if any, costly hand labor, and they may frequently be substituted for a number of tedious manual machining and joining operations. Electroformed shapes of uniform strength eliminate the need for brazed or welded joints. For tube-like or cup-like shapes, electroforming is especially efficacious since repeated drawing and annealing operations can be avoided.

The choice of metals and alloys adaptable to electroforming is nearly as wide as that offered by any other method of forming and, potentially, is much wider. Metallurgical control of properties for electroformed metal is rapidly becoming an exact science, and future development in electrochemical-metallurgical know-how is certain to be significant.

Continuous and Automatic Production of Electroforms

Equipment for the continuous production of sheet[40,42] and screen[36] have been described: deposits are formed,

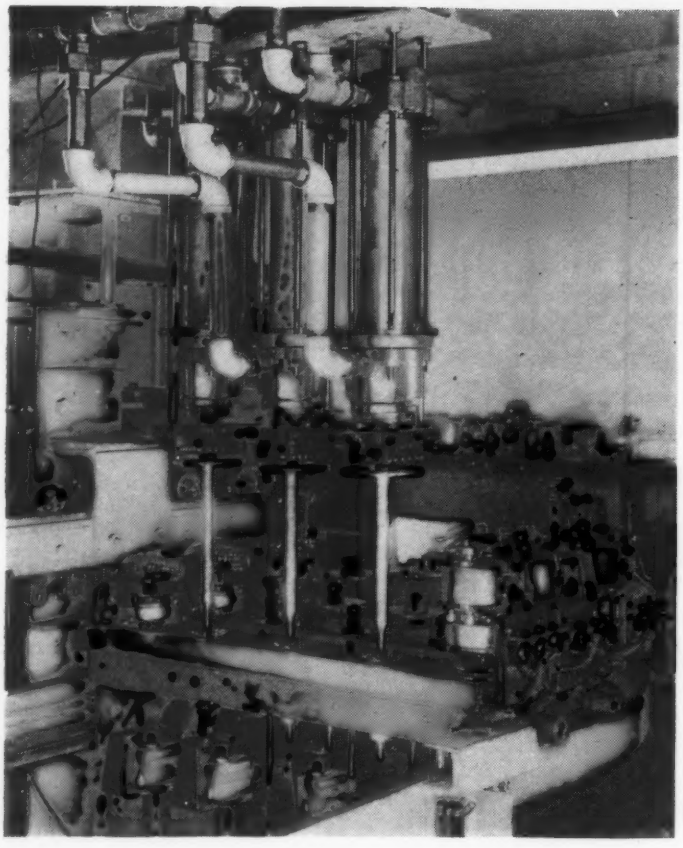

Fig. 2. Close-up of stripping station for electroformed caps

stripped from their base, and coiled in rolls by mechanical devices which are regulated and synchronized without dependence upon manual control. Sheet and screen manufacturers generally employ slowly rotating drums, which may be only partly submerged in electrolyte and which are resurfaced, if necessary, at the beginning of each new cycle. Continuous lengths of thin materials are produced with such drums; thicker gauges are built up, after stripping, by electroplating in auxiliary baths with equipment similar to strip plating machines.

A process for forming and stripping tubing continuously involves the formation of a new tube section on a corresponding mandrel section pulled out at regular, precalculated intervals[45]. Automatic equipment is also used insofar as possible for the production of band instruments[1] and sound-record dies[8].

A pilot plant was constructed for the continuous manufacture of fountain pen caps*. The process was designed to include electroforming, finishing, and stripping on an electrically powered and controlled conveyor with rotating mechanisms and lifting devices. Stripping was accomplished by impact of the electroformed caps against dies. Stripping hoists, mandrels, and other functional parts can be seen in Figs. 1 and 2. The same equipment was also used for making triangular tubes, lipstick containers, and hypodermic needles (Fig. 3). This type of equipment could probably be used to accomplish equal high-quality, low-cost manufacture of many articles that are concentric about one axis.

Metallurgical Properties of Electroformed Metals

Electroforming may offer a significant functional advantage frequently overlooked by fabricators. For specific applications, it is not unusual to obtain better metallurgical properties by electroforming than by casting, cold forming, etc. Stress-free electroformed nickel, for example, can be made much harder and with greater strength than is possible by cold rolling followed by stress relieving. Cold-worked electroformed copper is reported to have nearly twice the strength of hard-drawn copper wire[39]. The strength properties of annealed electrolytic iron are more similar to those of low-carbon steel than of ingot iron.

Adjustments of hardness and strength properties, which may frequently be extended over very wide ranges, are easily controlled since they may be secured by simple bath modifications, by addition agents to refine the grain structure, or by forming from alloy baths. There are two possible grain structure types, each serviceable for certain purposes. The columnar type, illustrated in Fig. 4, is usually soft and very ductile and may be preferred for some electroforms which must withstand post-forming fabrication. However, fine-grained structures, which may be made hard and tough, are usually selected because of their better strength or hardness and better resistance to wear and impact. A fine-grained structure, produced in a Watts bath containing benzene sulfonamide, is shown in Fig. 5. Exceptional tone qualities are obtained in trumpets as a result of grain-structure control of the electroformed bells.

The use of alloy deposits to improve strength, hardness, or corrosion resistance has not been exploited to the degree which it deserves. There were found in the literature only a few references to electroforming from alloys†. Electroforming with alternate layers of two metals (such as copper and nickel) was claimed, in certain instances, to provide increased strength. Products formed from two metals in alternate layers are electrotypes[11], foil‡, sound-record molds§, and sheet[4]. Carburizing of electroformed iron to make steel has been employed in an effort to improve properties‖.

Data on metallurgical properties for some of the

*A Battelle Memorial Institute research project, conducted for The Parker Pen Company. †U. S. Patents 895,164, 1,837,355, and 2,087,916. ‡U. S. Patents 676,357, 821,626, 865,687, 865,688, 879,859, 936,525, 1,379,089, and 1,709,801. §U. S. Patents 974,895, 1,011,838, and 1,029,965. ‖U. S. Patent 857,926 is the basic patent for this process.

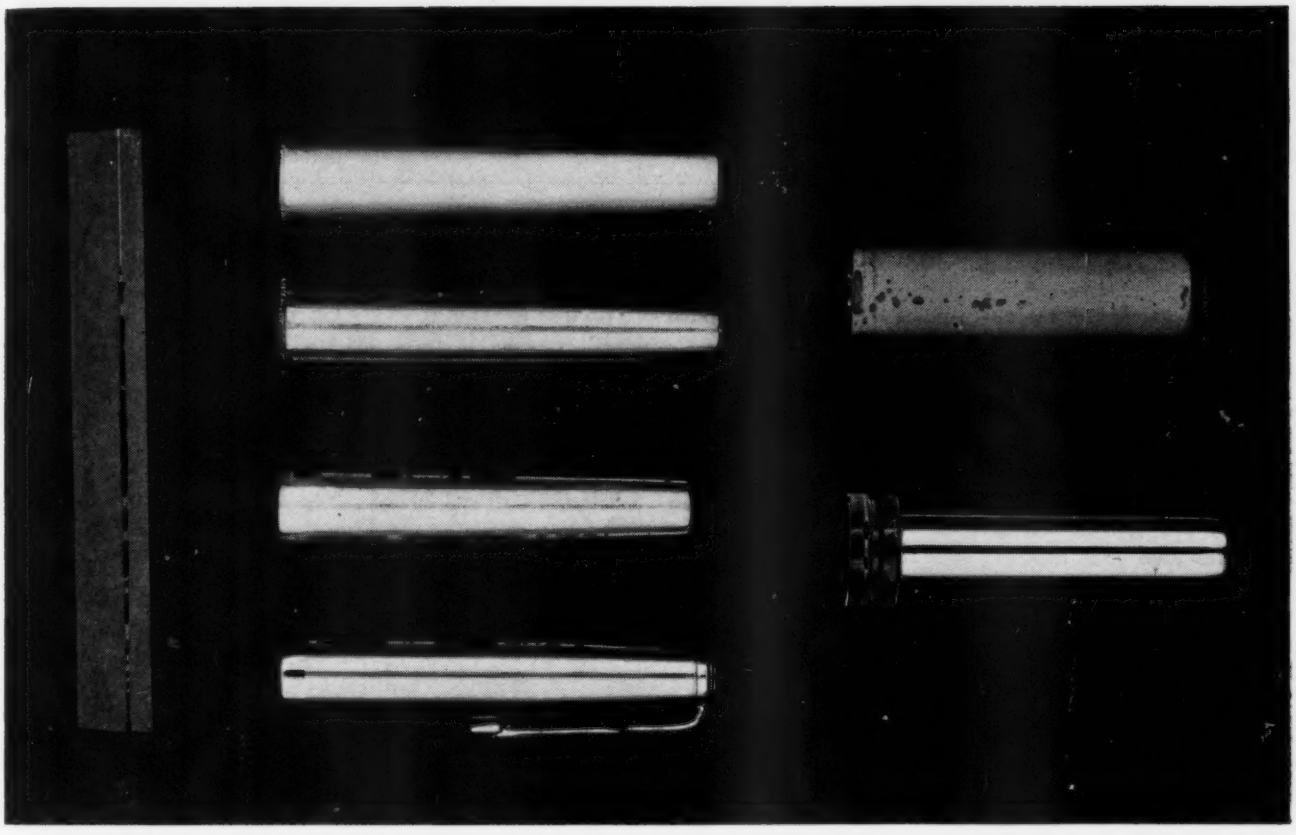

Fig. 3. Products electroformed by continuous and automatic pilot-plant process. From left to right and down: (1) section of electroformed, silver-lined rectangular radar tubing of nickel; (2) fountain pen cap, as formed, in a modified Watts nickel bath; (3) pen cap, as formed, of cobalt-nickel alloy; (4) pen cap, as formed, of silver-lead alloy; (5) electroformed nickel cap, after butler finishing and assembling; (6) lipstick case cover, as formed, in a Watts nickel bath, and (7) lipstick case cover formed in a bright nickel bath and chromium plated

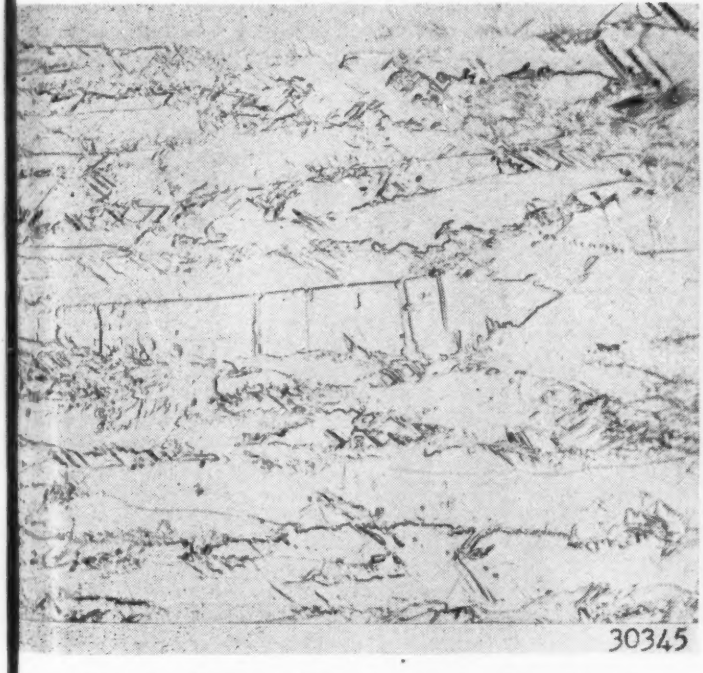

Fig. 4. Cross section of pen cap electroformed from a Watts bath, illustrating columnar type grain structure. Etchant 50 per cent by volume of each acetic and nitric acid. 500 X

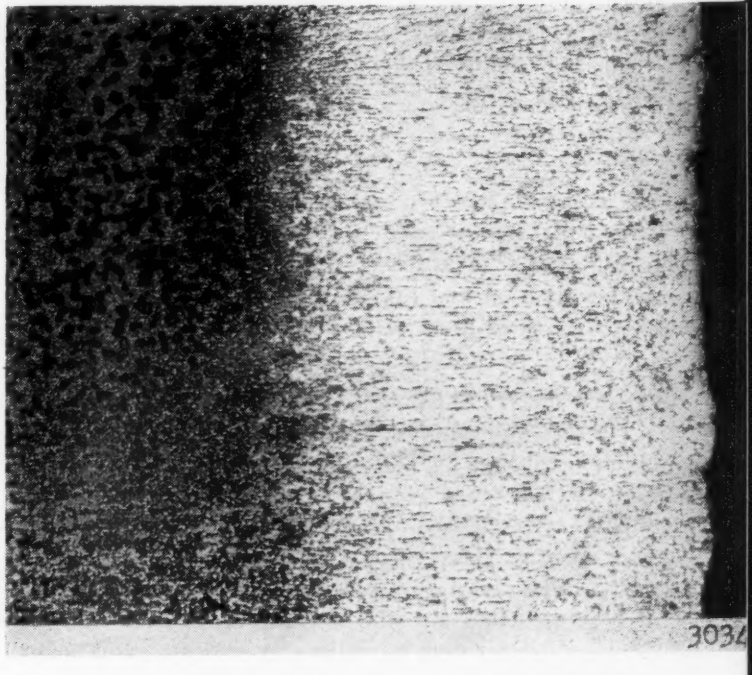

Fig. 5. Cross section of pen cap electroformed with a benzene sulfonamide addition to a Watts bath, illustrating fine-grained structure. Etchant 50 per cent by volume of each acetic and nitric acid. 500 X

TABLE I. PROPERTIES OF ELECTROFORMED METALS

Metal	Hardness Brinell or Vickers	Tensile Strength psi	Elongation per cent*	References
Nickel				
Hard, stress-free as-formed	130–500	Up to 132,000	Up to 20	4, 54, 57, 63
Very hard as-formed	400–575	Up to 160,000	Up to 9	61, 63, 65
Very hard stress-annealed	300–400	Up to 90,000	Up to 30	65
Fully annealed, re-crystallized	No data	45,000 to 55,000	Up to 50	4, 57
Copper				
Stress-free as-formed	30–120	30,000 to 68,000	5 to 20	4, 8, 19, 42
Cold-worked, ductile	65	Up to 102,300	40	45
Iron				
Stressed as-formed	225–350	50,000 to 110,000	5 to 20	6, 23, 30, 34, 38, 59, 60, 64
Annealed	140–165	40,000 to 55,000	27 to 40	6, 23, 56
Cobalt				
As-formed	150–375	No data	No data	58, 60
Silver				
As-formed	50–300	No data	No data	58, 63

*Reported in most cases as elongation in two inches.

metals used by electroformers have been published and are summarized in Table I. All of the values listed were determined for electroformed sections of sheet, tubing, or rod. The individual references should be consulted for details on test methods. Since different investigators used somewhat different methods of testing, the values reported in the table should be considered significant only for the purpose of visualizing possibilities for a particular metal.

Generally, the values for one or two properties define the ability of a product to meet service requirements. For example, the serviceability of a die is dependent, principally, upon resistance to abrasion and resistance to impact. A special test designed to produce accelerated abrasion and impact might serve better in the appraisal than hardness and strength measurements and could be used advantageously for both experimental work and production control.

The governing requirement for fountain pen caps is resistance to denting by impact. In experimental work with electroformed pen caps, a small facsimile of an impact tester (Fig. 6) was used to measure dent resistance as a function of measured impact from a moving knife edge. Dent resistance was measured for nickel, nickel-cobalt alloys, and silver-lead alloys. Changes in operating conditions, modifications in bath formulation, and various addition agents were investigated for their effects on this property.

For a modified Watts nickel bath, changes in current density over a wide range (100 to 500 asf), temperature between narrower limits (135° to 150° F), rate of mandrel rotation (from 150 to 400 rpm), *p*H (from 2.1 to 4.5), and metal ion concentration had little influence on "dentability". However, addition agents caused pronounced effects. These are summarized in Table II, which also gives values for caps formed from nickel-cobalt and silver-lead alloys. Changes in concentration of addition agents within the limits given

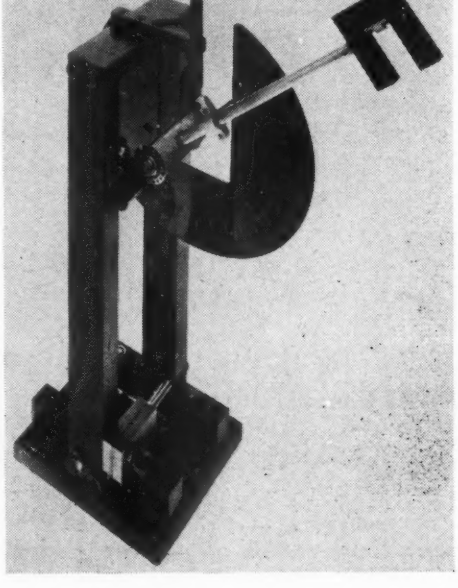

Fig. 6. Impact tester for measuring "dentability" of fountain pen caps

did not result in significant variations in dent resistance. The impact test was also used for control during pilot-plant development and was helpful in tracing embrittlement resulting from impurities leached from rubber-lined filters.

Separating Procedures and Stripping Methods

Electroforming differs from electroplating chiefly with respect to the adhesion of the deposited metal to its base. With a few exceptions, electroforms must be started on a base or preformed shape but must be readily separable therefrom after deposition is complete or during an intermediate stage. The starting forms are referred to in the literature most frequently as mandrels, molds, patterns, cores, impressions, and formers. They may be made of asbestos, asphalt, cloth, gelatin, glass, gutta-percha, metals, paper pulp, plastics, plaster, pottery and other ceramics, quartz, rubber, wax, or wood.

Metals are frequently preferred since they require no surface treatment for providing conductivity. Of these, chromium alloy steel, aluminum, magnesium, tungsten, molybdenum, tantalum, chromium plate over other metals, and, to a lesser degree, lead are particularly useful because good bond strength of deposited metal to base is not difficult to avoid and easy separation is thereby effected. These metals are examples of materials which can be used repeatedly without intermediate treatment or attention and are referred to as permanent mandrels.

Alloy steel, highly polished and plated with smooth chromium, was found to have especially good permanence because of its hardness and was used to produce an infinite number of accurately reproduced pen caps. With chromium-plated alloy steel dimensional accuracy can easily be held to 0.0001 inch.

Permanent mandrels are removed from their electroforms by impact, by applying tension, by prying with sharp knives, or by heating where differences in rate or coefficient of expansion occurs. Electroformed articles are also cold worked (by rolling or tumbling) to loosen them from base metal, a result of preferential expansion. A special technique, sometimes successfully employed, makes use of two or more threaded, interlocked sections. Surfaces are carefully lapped to insure continuous deposits over the joints. After forming, one or more parts are turned out, and the last section is dislodged by impact.

Other materials may be used as permanent mandrels. Rubber and some plastics which are formulated so as to be electrically conductive may be molded in desired shapes. They may offer the additional advantage of having greater expansion coefficients than metals and, thus, may be heated only slightly to rupture the temporary interface bond. Rubber, if molded in bag form, may be expanded or deflated at will and easily withdrawn from the completed electroform.

Semipermanent mandrels are those which are resurfaced or treated before each new cycle or re-use. Materials in this classification, which can be highly polished so as to reproduce fine detail and which have a good degree of permanence, include steel, copper, brass, glass, and the hard thermosetting plastics. Steel is plated with tin or cadmium, which is melted after electroforming is completed, and is then replated for a new cycle[7]. It is said that dimensional tolerance for this procedure is 0.0002 inch[34]. Polished glass is coated with silver reduced from an ammoniacal salt solution to produce an equivalent dimensional accuracy[30].

Colloidal graphite is applied to metals as a separating medium[51]. Films up to 0.005 inch may be built up by successive brush applications with a 10 per cent aqueous dispersion. Pre-heating the metal before

TABLE II. ESSENTIAL DATA RESULTING FROM EFFORTS TO INCREASE DENT RESISTANCE OF ELECTROFORMED PEN CAPS

Bath	Addition Agent	Addition Agent Concentration g/l	Impact Resistance inch dent / inch-lb Impact*	Hardness Knoop
Watts nickel	None	.....	0.012 to 0.014	165 to 250
Watts nickel	Sodium formate	5.0 to 30.0	0.006 to 0.009	Not measured
Watts nickel	Saccharine	0.2 to 2.0	0.003 to 0.004	Not measured
Watts nickel	Benzene sulfonamide	0.05 to 2.0	0.002 to 0.004	485 to 595
Watts nickel	Toluene sulfonamide	0.2	0.001 to 0.003	Not measured
Watts nickel	Naphthalene disulfonic acid	0.02 to 1.8	0.001 to 0.002	Not measured
Cobalt-nickel	(14–18 per cent cobalt)	.....	0.005 to 0.009	Not measured
Silver-lead	(5–6 per cent lead)	.....	0.003 to 0.005	Not measured

*Load for dents greater than 0.010 inch/inch-lb equal to 2 inch-lb.; less than 0.010 inch/inch-lb, 3 inch-lb.

application has been recommended, but temperature, colloid concentration, and rate of application must be controlled empirically[52]. Some of the procedures for metallizing glass and other ceramics[50] are equally adaptable to metals. Steel and other metals may be coated with a lead powder-graphite mixture with good results. Films produced in solutions of selenium or arsenic salts, metal sulfides or chromic acid, and with collodion or mercury amalgams have also been given as examples of separating media for metal from metal. Brass may be electropolished and treated to prevent intimate bonding to nickel or copper deposits.

Starting materials which may be used for a small, limited number of reproductions are wood, wax, plaster, and thermoplastic resins. They are metallized by spraying, brushing, or dipping in graphite or metallic powders or paints. Wood and plaster must be waterproofed before the conducting film is applied. This may be done with a wax or varnish. Plaster can be waterproofed and graphitized in one operation by coating with a paint dispersion of graphite or with a plasticized composition which can be subsequently polymerized. The application of graphite to wax surfaces is a tedious and difficult operation but is sometimes necessary, or at least desirable, if a better material is not readily available or cannot be easily made into a pattern.

Ceramics can be molded, fired, and coated with a matrix containing electrically conductive salts, powders, or pigments which are then fused in a furnace. In this case, as with plastics, allowance must be made for shrinkage.

Temporary mandrels are made for a single electroforming cycle and are destroyed or deformed when deposition is completed. Low-melting-point alloy formulations including lead, tin, bismuth, cadmium, and/or mercury were disclosed in patents more than fifty years ago. The alloys manufactured by the Cerro de Pasco Corporation cover a wide range of melting points and are well known as modern examples of controlled compositions with sharply defined melting points[37]. It is said that the dimensional accuracy obtainable with electroforms of fusible metal mandrels, of about 0.002 inch[34], is less than that from permanent metal mandrels.

For very small sections, casting difficulties with blowholes and irregular surfaces may be eliminated by centrifugal casting or with vacuum techniques. Low-melting alloys, because of their low surface tension and good wetting quality, are generally difficult to remove completely from the inside of small recesses. In this case, an easily soluble alloy may be chosen for removal by chemical dissolution of the mandrel.

Aluminum, zinc, copper, brass, silver, and other metals are cast or machined into mandrels and subsequently dissolved chemically or electrochemically. Dimensional precision with dissolvable materials, especially if machined or die cast, is better than with fusible mandrels. Thus, they are frequently useful for intricate shapes demanding very close dimensional tolerances. Temporary dissolvable mandrels are especially useful for experimental work on new products since they can be made more cheaply and easily than permanent mandrels from harder materials.

Aluminum and zinc foil are efficacious for reproducing relatively plane-surfaced objects. A negative is made simply by pressing the foil against the article to be reproduced.

Many different recommendations for mandrel materials may be found in the literature. Several different kinds of formers are usually given as examples by different manufacturers of the same article and are frequently mentioned by the same author.

The producers of radar cavities and of bells for musical instruments, for example, employ both semipermanent and temporary mandrels. Nearly all electrotype and sound-record starting forms may be classified as semipermanent. Some are pressed from plastics which are resurfaced with a conducting film before each new electroform is started. But temporary fusible metals and wax impressions are also used to a large extent. Sound-record originals of wax are made conductive by metallic deposition from vapor phases. Graphite mixtures or chemically reduced "silver mirrors" or other "metal mirrors" are applied to wax electrotypes. Permanent chromium-plated electroformed copper positives are used for quantity reproduction of sound-record stampers.

In the references to electroformed molds, both permanent and semipermanent rubber patterns and temporary plaster patterns are cited. The patents relating to sheet, strip, and foil mention many different materials having different classifications. Screen and tubing are started, generally, on permanent metal surfaces and on metals belonging to the semipermanent class. For heat exchangers, fusible or easily dissolved formers are usually specified. Workers with jewelry and ornamental items ordinarily employ wood, wax, plaster, and similar materials, easily shaped but capable of reproducing only a limited number of electroformed replicas. For very large objects, tank wall sections are bolted together, filled with electrolyte and made electrically negative in order to form seamless tanks, kettledrums, caskets, etc.

While recommendations concerning optimum materials and stripping procedures for new kinds of articles to be electroformed cannot be made with precision, they may be helpful in visualizing possibilities. Too often, a material is chosen because of its greater familiarity to the investigator than for functional reasons. A list of materials believed to be suitable for various kinds of articles is given in Table III.

There are a few examples of electroforming where mandrels are not required. For example, a patent for

TABLE III. MATERIALS RECOMMENDED FOR ARTICLES OF CERTAIN CLASSES

Class of Article	Suitable metals for Forming*	Recommended Kind of Mandrel
I. Low-cost, mass-produced shapes with simple design		Permanent mandrels of alloy steel
(a) Corrosion resistance unimportant	Copper, iron	
(b) Good resistance to corrosion	Cobalt, nickel, nickel alloys	
II. Similar to I but with higher allowable material costs	Silver alloys, gold alloys, copper or nickel, plated with rhodium	Permanent or semipermanent mandrels
III. Mass-produced, intricate shapes, liberal dimensional tolerances	Same metals as listed above, choice dependent on cost allowances	Temporary mandrels of fusible metals
IV. Mass-produced, intricate shape, close dimensional tolerances	Same metals as listed above, choice dependent on cost allowances	Temporary mandrels of dissolvable metals
V. Simple shapes, great hardness and strength, close dimensional tolerances	Nickel, nickel alloys, iron	Permanent or semipermanent mandrels
VI. Similar to V, liberal dimensional tolerances	Nickel, nickel alloys, iron	Semipermanent or temporary mandrels

*Recently disclosed chromium-plating methods offer possibilities for Classes I and V, in particular the so-called "machinable" or the "low-contraction" chromium.

forming wire discloses a procedure for depositing copper on a preformed wire end*. Several patents discuss procedures for making multiple, successive layers of sheet or foil on a single, pre-electroformed starting sheet.

Special Electrodeposition Techniques

Since thickness of electroforms must usually be several times that of electroplates, baths and operating conditions efficacious for very high-speed deposition rates are preferred. Nickel baths, for example, are nearly always operated at current densities above 200 asf (0.01 inch/hr), which is seldom reached in decorative plating. Methods and rate of agitation, tailormade for each article, can be chosen so that greater current densities can be applied.

Round, symmetrical objects are rotated during electroforming. The surface speed determines the maximum practical current density. Fountain pen caps with a diameter of less than ½ inch could be rotated with a peripheral speed of only 50 ft/min, thus limiting the current density to about 400 asf.

Shapes with plane surfaces, not easily rotated, are more amenable to solution circulation, which can be adjusted to very high rates so that current densities up to at least 2000 asf are possible. High-speed jets may be impinged directly during electroforming. A current density of 2000 asf is reported with jets of copper electrolyte on rotating sound-record stampers[8]. Air agitation is regularly employed in copper baths in addition to other methods of agitation. Electroforming deposition rates, reported in the literature for some of the electrodeposited metals are summarized as follows:

Copper	0.005–0.1 inch/hr
Iron	0.001–0.003 inch/hr
Nickel	0.01–0.1 inch/hr
Silver alloy	0.003–0.03 inch/hr

It is understandable that smooth deposits are more difficult to obtain for thick electroforms than for thin decorative plates. Those who have produced electroformed articles have demonstrated repeatedly that acceptable smoothness can be obtained for thicknesses up to ¼ inch. Careful control is, of course, necessary. Filtration methods and rates may seem fantastic to many job platers, but they have been shown to be both practical and economical†.

Designs for tank and agitation equipment to minimize the effect of dirt precipitated from the air should

*U. S. Patent 1,965,39. †In this instance, electroplaters could well afford to simulate the techniques of electroformers.

be evaluated for their effects if air filtration is not possible. Fluid flow should be directed so as to minimize dirt contact with the work until the dirt either drops below the work or enters the filter lines. The solution below the work should be uniformly drained from the bottom of the tank or allowed to remain stagnant. Chips from moving machine parts (gears, chains, brushes, commutators, etc.) must not be allowed to enter the electrolyte, nor to collect on surfaces adjacent to the bath.

Insoluble anodes are sometimes preferred[1,39,40] in order to obviate nodules likely to be formed from anode particles. In this case, metal ion concentration is restored in a separate corrosion cell or replenished by addition of metal carbonate, other salt, or oxide.

Metal fabricators generally think of electroforming as limited in wall thickness to a fraction of an inch, but electrodeposition can faithfully reproduce significant surfaces with only a few thousandths inch wall, which can be subsequently built up by casting, brazing, welding, metal spraying, or sputtering to the desired thickness of the finished article. Electrotypes, dies, molds, rolls, and tanks are produced by such procedures.

Thickness uniformity is very important and is generally controlled more accurately than in commercial decorative plating. Special techniques which are frequently employed include the use of (1) conforming anodes, (2) bipolar electrodes, (3) current-insulating shields, and (4) current robbers. These procedures have been adequately discussed in the literature and need no detailed explanation at this time. Since metal costs must usually be kept at a minimum, the last-mentioned practice is seldom employed.

Because conforming anodes from soluble metals are difficult to maintain, they are made almost exclusively from insoluble materials. Alloy lead is used in both copper and nickel baths.

Current-insulating shields or dams of glass or various plastics are developed by trial and error, but a knowledge of primary current and polarization effects are essential for the experimenter. Some plastics are not acceptable for use in contact with metal cathodes because they absorb electrolyte and serve as a base for metal deposition. Glass, ceramics, polystyrene, polyethylene, and some rubber compositions have been found serviceable.

Some simple shapes can be formed with a uniform wall by simply regulating anode placement. For example, pen caps with a wall of 0.010 inch and a tolerance of 0.0005 inch were made with ½-inch anode widths positioned 1 inch from rotating cathode surfaces and approximately midway between the top and bottom of the caps. Koroseal strips were laid on both sides of the anode before bagging, and reduced current distribution to the ends of the caps. A small plastic disc held from the bottom of the mandrel by a tapered pin prevented beading.

It is sometimes desirable to distribute metal unevenly to satisfy a predesigned specification for extra strength over part of the total area. This can usually be done by special current dams. Hypodermic needles were formed with the hub walls twice as thick as the needle walls by completely shielding the entire length of the needle and the lower portion of the hub. Shields were positioned slightly nearer to the cathodes than they were to the anodes. Wall thickness along 2-inch needle lengths was essentially uniform: variations were less than 10 per cent and there was no bead at the bottom.

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Physical Properties of Electrodeposited Metals

I. NICKEL

1. Literature Survey

COMPOSITION AND STRUCTURE

The first phase of Research Project No. 9 deals with the physical properties of electrodeposited nickel. This report is a survey of the literature and contains a bibliography of the pertinent papers. No experimental work of this project is included in this report.

It has long been recognized that the physical properties of a metal may vary widely, depending on its history. The properties may be affected by the method of preparation, mechanical working, heat treatment, presence of impurities, and type of microstructure. The properties of electrodeposits are generally quite different from metals in the wrought or cast form.

This review of the literature has been directed chiefly to the properties of pure electrolytic nickel, though some values for other forms of nickel have been included for comparison. Except for mechanical properties, such as hardness and tensile strength, little study has been made on the properties of nickel as deposited. It was usually annealed before testing.

Composition

Electrodeposited nickel may contain hydrogen and oxygen, either occluded or chemically combined, along with small amounts of copper, iron, silicon, carbon, sulfur, and cobalt. The cobalt is usually included with the nickel in the chemical analyses of nickel. Up to 0.007 per cent (by weight) or 7 volumes of hydrogen have been found in nickel deposits[78], while oxygen contents of 0.004 to 0.5 per cent (by weight) have been reported[42,92]. The content of oxygen is related to the *p*H of the plating solution.

Types of nickel, physical properties of which have been measured, are listed in Table I. The letters in the first column will be used in this report to identify these materials.

Structure

The crystal structure of electrodeposited nickel may vary considerably with the conditions of deposition. One may obtain large crystals of columnar, fibrous, or broken types, which are typical of soft deposits; or fine crystals that may not be resolved under the optical microscope and are typical of hard deposits; or fine crystals with a laminar structure that are typical of bright deposits; as well as intermediate types. On annealing of any of these deposits, crystal growth takes place. If the annealing is sufficiently prolonged and the temperature is high enough, large equi-axial crystal grains will be obtained and deposits of the same chemical purity will tend to approximate each other in properties. The crystal size of nickel may vary from 10^{-2} to 10^{-6} cm, depending upon conditions of deposition.

Deposition of crystals with preferred orientation is common, and the properties of the deposits may depend upon the type and degree of orientation. There are many examples of the deposit reproducing the grain structure of the basis metal, most notable of which are those of Hothersall[76]. He reported reproduction of the crystal structure of the base metal by deposits of metals with lattice

parameters that varied as much as 12.5 per cent from that of the base metal. The extent of reproduction is dependent upon the crystal size of the substratum, with larger crystals having greater effects than smaller crystals. The bath composition, current density, temperature, and other factors which influence the rates of formation of crystal nuclei and of crystal growth, all affect the reproduction. The crystallographic plane that lies in the plane of the cathode surface may also affect the degree of crystal reproduction.

The question has been raised, "Is the reproduction actually a continuation of the crystal lattice of the base metal or is it merely a reproduction of crystal size and shape?" Clark, Pish and Weeg[138] by X-ray and electron diffraction found that in a few transitional layers the crystal arrangement simulated and extended the type and dimensions of the crystal lattice of the basis metal, but that the structure soon changed to one typical of the deposit for that bath and its operating conditions.

Examination of the microstructure provides invaluable evidence which cannot be reliably deduced from the surface appearance of the deposit. Alone, however, it is inadequate, particularly with fine-grained deposits in which substantial changes in structure (revealed by physical tests) are possible without appreciable changes in microstructure.

The use of X-rays has been of considerable value in gaining information, especially about fine-grained deposits, beyond that revealed by the microscope. It is known that hard electrodeposits have a small grain size, which may be too small to be resolved under the optical microscope. X-ray diffraction methods give information about the size of these smaller grains and also the degree to which they are oriented. X-ray spectral lines are broad and diffuse for hard nickel deposits, the broadening of the lines corresponding to a decrease in grain size. If the width of a given X-ray line of an annealed metal is plotted against the percentage reduction in thickness by cold working[80], the line breadth first increases rapidly in the early stages of reduction and then approaches a definite limiting value which is characteristic of the metal and is independent of the mode of deformation. In contrast, electrodeposited coatings may give lines so broad as to be diffuse. The difficulty of indefinitely diffusing the spectral lines of an annealed metal by cold working suggests that at ordinary temperatures there is a lower limit to the grain size to which an annealed metal can be broken down. Attempts to break down the grains below this limit must then be countered by recrystallization. However, electrodeposits of chromium and nickel have grain sizes much smaller than this limiting value. The lines may also be broadened by lattice distortion, but grain size is the major factor. Wood suggests[79] that metal coatings may contain stresses sufficiently intense to inhibit grain growth and to keep the grains smaller than this limit. Such an effect may result from occluded oxygen and hydrogen.

X-ray examination of nickel and chromium coatings showed a relation between the perfection of the orientation and the brightness of deposits, and also a relation between the hardness of the coatings and the broadening of the spectral lines. It was found that if the metallic coatings are placed in order of hardness, the X-ray spectra vary regularly in the degree of diffuseness; the softer coatings correspond with sharp spectral lines and the harder with broad lines. Desch[77] has suggested that the hardness is not controlled solely by grain size, but that it may also be increased by the presence of the non-metallic particles in the deposit in a critical state of dispersion. These interfere with slip and cause hardness by a mechanism resembling that ascribed to dispersion-hardened alloys such as duralumin.

Numerous theories have been offered to explain fine-grained, hard electrodeposits. Many of the earlier workers have ascribed the hardness to the presence of hydrogen, either as a hydride or a solid solution. The work of Guichard[66] and others has shown that about 90 per cent of the hydrogen present in a deposit can be removed by heating the metal in a vacuum, without appreciably softening it. It has been shown that a relation between the hydrogen discharged during plating and the hardness exists in only a restricted range and below a critical *p*H, and that even there the correlation is poor[60].

A plausible theory has been put forth by Macnaughtan, Gardam and Hammond[60]. They suggest that the hardness is a result of extremely fine grains which, in turn, are caused by interference with crystal growth exerted by colloidal nickel hydroxide or other basic compounds that are precipitated at the cathode surface and occluded in the deposit. The presence of these colloidal nickel compounds was shown by annealing hard deposits at high temperature which caused non-metallic inclusions to become visible under the microscope in amounts which increased with the initial hardness.

Pure metal without inclusions can be deposited only from plating solutions that are free from impurities, colloidal or otherwise. Such a deposit consists of large crystals, and its mechanical properties approach those of annealed metal. The medium sized inclusions have little effect, and large local inclusions produce an abnormal orientation of the crystals and refine or enlarge the grain size according to their size, shape and position. These effects of inclusions influence the properties of electrodeposited metals.

Bright nickel deposits are abnormally hard and fine-grained. Their microstructure does not reveal crystal grains but shows definite lines representing laminations parallel to the base metal. All these lines are not equally visible under the microscope, and their number seems to increase with the magnification. The close spacing of these layers is about at the limit of a metallurgical microscope (2500X)[115].

Considerable effort has been made to determine the nature and cause of these layers and, particularly, to correlate them with other factors, but no satisfactory explanation has yet been obtained. It was considered that the difference in the rates of etching might be caused by differences in chemical composition or in stress, but no definite evidence has been given to support these views. When a portion of a deposit had been heavily deformed in a Brinell hardness-testing machine, examination of the deformed area showed that the lines had not been eliminated, but that flow of the deposit

TABLE I. COMPOSITION OF NICKEL (Wt. %)

Type	Ni	Co	Fe	Cu	Mn	Si	C	S
(a) Very pure electrolytic nickel	99.99	0.0003	0.0005	0.0008	.....	.....	.....	.....
(b) Purified electrolytic nickel, vacuum melted	99.94	0.016	0.03	0.006	.....	0.006	0.005	0.004
(c) Carbonyl nickel shot....	99.90	None	0.03	0.006	.....	.....	0.005	0.001
(d) Commercial wrought or "A" nickel....	99.4*	.....	0.15	0.1	0.2	0.05	0.1	0.005

*Nickel plus cobalt.

had occurred chiefly by slip on comparatively widely separated slip planes, giving the parallel lines a step-like appearance. X-ray examination of bright nickel deposits yielded broad spectrum lines, which indicate very small grain size. Some, but not all, showed preferred orientation.

The effect of annealing electrodeposits is to cause an increase in grain size, to segregate non-metallic material, and to liberate gases which may have been occluded or chemically combined in the deposit. The grain growth that occurs during annealing is related to the original structure and hardness. Considerable restriction of grain growth by segregation of non-metallic material has been observed, particularly in deposits produced under conditions which result in the inclusion of relatively large amounts of basic material.

On annealing deposits of nickel, gas is evolved, the amount and kind varying with the temperature of heating and the conditions of deposition and storage. Most of the hydrogen is evolved at from 200 to 500° C; the remainder, believed to be chemically combined, is evolved at higher temperatures[66,73]. Carbon monoxide is not liberated in any quantity below 600° C[117]; it has a low diffusibility[89].

Certain deposits of nickel decrease in density and electrical conductivity and increase in brittleness on annealing at temperatures above 600° C. This has been attributed to the evolution of gases, probably from inclusions, which loosen the intercrystalline structure with the formation of hollow spaces and voids[117].

Softening of electrolytic nickel takes place from about 300 to 600° C. The extent and range of softening depend upon its purity, amount of cold work, microstructure, and the presence of internal stress. For severely cold-worked electrolytic nickel, the recovery range may be lowered to 200–300° C[108]. The results of McCutcheon[108] show the effect of annealing temperature on the broadness of the X-ray diffraction lines. Evidence of recrystallization after annealing at various temperatures may also be obtained from photomicrographs.

The temperature of recrystallization of bright nickel deposits is dependent upon the bath and conditions of deposition. One deposit showed clear evidence of recrystallization at 300° C, while all the bright deposits examined showed crystal growth up to 1000° C. A deposit from a formate bath after annealing at 700° and 1000° C showed very large grains, similar in size to those found after annealing cold-rolled commercial nickel under comparable conditions; the grain boundaries of these annealed "formate" deposits were sharp and comparatively free from foreign matter. It has been suggested that the basic compounds were reduced by included organic materials, since carbon was found in all of these deposits. Annealed deposits of similar hardness and microstructure produced in a solution free from organic matter had a small grain size and a large amount of foreign matter in the boundaries[116].

Physical Properties

Mechanical Properties

The values of mechanical properties may vary somewhat with methods of measurement and may not be very reproducible, especially if pits or inclusions are present. Measurements on several specimens are necessary to yield a reliable value for a property.

TABLE II. TYPICAL VALUES FOR MECHANICAL PROPERTIES OF NICKEL

Type	Hardness Brinell	Tensile Strength psi	Elongation % in 2 inch (5 cm)
Pure annealed (a)	70	46,000	.....
Cold rolled, annealed (d)	90–130	65,000–80,000	45–50
Cold rolled, hard (d)	180–250	90,000–115,000	15–30
Cast (d)	80–125	55,000–70,000	15–30
Electrodeposited, from sulfate-chloride solutions	120–420	50,000–160,000	1–30
Electrodeposited, from bright nickel solutions	up to 550	.....	.....

1. Hardness. Hardness is the property of electrodeposits most often measured because of its relation to the service life of the deposit. The hardness of electrodeposited nickel is considerably higher than that of annealed nickel and is frequently higher than that of the cold-worked metal. The hardness of deposits is generally measured in the plane normal to the base metal, although it is recognized that directional effects may be present owing to the anisotropic nature of electrodeposits. It has also been pointed out that differences exist between the hardness of the inner and the outer surfaces of deposits[134].

The hardness of electrodeposited nickel depends upon the bath composition, *p*H, current density, temperature, and agitation. The effect of each factor is not independent but is related to all others.

Hard nickel deposits have been obtained from sulfate-chloride baths operated at a high *p*H. Reduction of *p*H causes a marked decrease in hardness until a critical *p*H is reached below which the hardness is more nearly constant. The relationship between hardness and *p*H, especially at a low *p*H, depends upon the presence of chloride and of other ions such as potassium. Potassium ions appear to make the deposits harder in baths with chloride and softer in baths without chloride[48,60].

For a modified Watts-type bath, which produces soft to medium-hard deposits, the hardness increased with increasing chloride content and was affected but little by the content of sulfate or boric acid[133]. Ammonium ions increased the hardness of deposits from the Watts-type bath. In nickel sulfate-ammonium chloride baths, which produce hard deposits, the hardness increases with an increase in *p*H and current density and decreases with an elevation in bath temperature[134].

Concentrated nickel chloride-sulfate baths operated at a high temperature (100° C or 212° F) yielded harder deposits when all or part of the nickel was present as nickel chloride than when all the nickel was as nickel sulfate. An increase in *p*H did not affect the hardness of deposits from all-chloride baths but increased the hardness of deposits from all-sulfate baths. In general the deposits obtained at 190° C had a lower hardness (120 to 230 Brinell) than those obtained at lower temperatures[74].

2. Tensile strength and ductility. Deposits from nickel-sulfate baths (no chloride) had tensile strengths varying from 60,000 to 128,000 psi and elongations from 3.5 to 12 per cent. Increasing the *p*H of the bath increased the tensile strength and decreased the ductility of the deposit. Increasing the current density increased the tensile strength. The tensile strength of deposits from baths at 100° C varied from 54,000 to 68,000 psi and the elongation from 5 to 23 per cent[74].

With the Watts and modified Watts-type bath, the tensile strength varied from 50,000 to 66,000 psi. As the *p*H was increased to above 4, the tensile strength increased greatly. In a nickel sulfate-ammonium chloride bath, deposits with 156,000 psi and 6 per cent elongation were obtained[134]. With nickel chloride baths (no sulfate), the tensile strength was around 100,000 psi with from 14 to 20 per cent elongation[121].

Upon annealing nickel deposits from sulfate-chloride baths at 1000° C (1932°

F) for 4 hours, the tensile strength decreased and the elongation increased[57]. Deposits from baths at a high *p*H decreased in tensile strength more than those from low *p*H baths. The elongation usually, but not always, increased upon annealing. This change in elongation varied with the *p*H of the plating solution, but the effect was not the same for all baths. These changes on annealing samples from high *p*H baths are related to the segregation of the basic material present in these deposits.

3. Modulus of elasticity. The modulus of elasticity of pure nickel varies from 30 to 32 x 10^6 psi. No data are available for electrodeposited nickel of known history.

4. Fatigue strength. The measurements of fatigue strength are difficult to interpret because they are affected by directional factors and the form of the specimen. Electrodeposited nickel sheet, 0.01 inch in thickness and with a tensile strength of 110,000 psi and an elongation of about 7 per cent, had a fatigue limit in reversed bending of 43,000 to 46,000 psi for 2 x 10^8 cycles[152]. Nickel wire of 99.56 per cent purity had a fatigue limit of 49,500 psi when tested in a rotating-wire arc-fatigue machine for 10^8 cycles[127].

5. Coefficient of friction. No data were found on the coefficient of friction of electrodeposited nickel of known history. Tests on the dry kinetic friction of ordinary polished nickel gave coefficients of friction of 0.53 for nickel on nickel, 0.56 for nickel on glass, 0.66 for nickel on steel. A larger coefficient of friction was obtained for dissimilar than for similar metals[119].

6. Stress. Stress within an electrodeposit is complex and is important because it must be considered in the measurement of any physical property. In response to a letter requesting information on the physical properties of electrodeposited nickel, many interesting and informative replies were received in which the principal comment was the desirability of measuring the stress in deposits. In the interpretation of stress measurements, the type of bath used, the conditions of deposition, and the method of measurement must be taken into account.

High stress in a deposit will be evident in many ways. If the cathode be of thin or ductile material, it may be warped or distorted by depositing metal upon it. If the stress is greater than the tensile strength of the deposit and the base metal is rigid so that there is no opportunity for the stress to relieve itself, a network of cracks may form or peeling may occur. These effects are important in electroforming, in protection against corrosion, in material to resist fatigue and in all plating where adherence is important.

The principal method used to measure stress in electrodeposition is to note the extent of bending of a cathode of thin sheet metal, e. g., steel or platinum, which is fixed at one end. The extent of bending is a measure of the stress in the deposits. This device is called a "contractometer".

Most nickel deposits (excepting some from baths with specific addition agents) show contraction during deposition. The magnitude of the stress, which may be as high as 52,000 psi, is dependent upon a number of variables[141]. In the normal Watts-type bath, increasing the temperature decreases the stress, while increasing the current density increases it. Below about 5, the effect of *p*H is slight, but above 5, the stress increases sharply with *p*H. Increasing the chloride content of the bath was found to increase the stress while the concentrations of nickel or boric acid had practically no effect. Superposing A. C. upon D. C. was found to decrease the stress. A plated cathode, bent by the stress of the deposit, will straighten on being heated.

Evaluation of the effect of impurities is difficult[4,12,141]. Ammonium and magnesium ions have been found to decrease stress as have formates, acetates and citrates. Iron, chromium, and aluminum increase stress. The effects of alkali metals depend upon the bath conditions. Small amounts of lead, copper, zinc, and calcium do not affect stress. Depolarizers such as H_2O_2 and certain unsaturated organic compounds have been reported to reduce stress.

Hothersall and Gardam[116] measured the stress in three types of bright nickel deposits, two of which showed contraction while the other was nearly stress-free or slightly expanded. As all three were hard deposits, hardness is not necessarily parallel to stress. The stress in the two bright deposits was slightly higher than in the Watts-type deposit. Addition of sodium naphthalene trisulfonate to a Watts-type bath caused a reduction and finally a reversal of stress. This effect of certain brighteners in reversing the direction of stress has been confirmed by other workers[141], and compressive stresses of approximately 10,000 psi have been reported.

There is no theory that fully explains the cause of stress in electrodeposits. Early theories associated the stress with hydrogen, while later the co-deposition of basic material was suggested as the cause. Peeling of films of nickel deposited from the vapor state on cold metal surfaces was found by Otis[61]. He attributed this to stresses, mainly tensile, arising during the condensation. This work suggests that the mere formation of a distorted metallic lattice, atom by atom at a sufficiently low temperature, creates intense stresses, and that the stress in electrodeposits is connected with the conditions when the metal lattice is formed.

Dimensional Properties

1. Density. The density of electrodeposited nickel appears to vary with small contents of impurities and heat treatment. Some values for the density of different types of nickel at 25° C are given in Table III[40,135].

a. e. s. research

TABLE III. DENSITY OF NICKEL

	g/cm³
Calculated from lattice constants	8.908
Pure (b), as cast	8.907
Pure (b), worked and annealed	8.901 to 8.904
Electrodeposited	8.88 to 8.90
Commercial (d)	8.88

The crystal form of nickel is face-centered cubic. The edge of the cube for pure (a) nickel is 3.517×10^{-8} cm at 25° C[135].

Thermal Properties

1. Melting point. The melting point of pure (b) nickel is given[40] as 1455° C; for commercial wrought nickel, it varies[144] from 1435 to 1445° C. The principal difference in values is caused by the impurities present. The melting point of electrodeposited nickel should correspond to the above values, with any variations being caused by the small amount of impurities.

2. Specific heat. The specific heat of cathode nickel annealed in vacuum at 700° C is 0.1112 cal/g/°C at 0° C and 0.1222 at 100° C[111].

Electrolytic nickel has a specific heat slightly higher than nickel obtained from nickel carbonyl. This difference has been attributed to the cobalt content (0.4 per cent), because heat treatment did not seem to affect the curve of specific heat versus temperature[111].

The specific heat rises to a maximum in the vicinity of the Curie point, the temperature of transformation from ferromagnetic to paramagnetic nickel (353 to 358° C).

3. Temperature coefficient of expansion. The temperature coefficient of expansion of pure (a) nickel is 12.5 x 10^{-6}/° C at 20° C and 13.5 x 10^{-6} at 100°C [128]. For ordinary commercial nickel (d) the value given is 13 x 10^{-6}/° C at 100°C [135].

In the vicinity of the Curie point there is a volume change and a break in the coefficient of expansion-temperature curve.

4. Thermal conductivity. The thermal conductivity at 100° C of pure (a) nickel was reported[72] as 0.198 cal/cm²/sec/° C and that of commercial wrought nickel as 0.155. Electrolytic nickel as

deposited would be expected to give slightly higher values, and the curve for thermal conductivity against temperature for the initial heating cycle would be different from that for the cooling cycle.

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Electrical and Magnetic Properties

1. ELECTRICAL. As the electrical resistivity and temperature coefficient of resistivity of nickel are very sensitive to impurities, they are good criteria of purity. The temperature coefficient of resistivity has the added advantage that its measurement does not involve knowledge of the cross-sectional area of the specimen.

The increase in electrical resistivity of nickel caused by impurities varies with the kind and amount of impurity. On a weight basis, the impurities iron, copper, manganese, magnesium, silicon and carbon in order of increasing effect, cause a rise in resistivity[135].

Data on the resistivity of nickel in the electrodeposited state are meager, because most of the specimens had been annealed prior to measurement. The resistivity of thin electrodeposited films from 6 to 75 x 10^{-5} cm thick was found to depend upon their thickness. For films about 1 x 10^{-5} cm thick, the resistivity was about twice that computed from their thickness and the temperature coefficient was about 0.7 that of bulk nickel[65].

2. MAGNETIC PROPERTIES. The magnetic properties of nickel are dependent upon the physical state of the metal and on the kind and type of impurities present. The Curie temperature is not a good criteria of purity owing to the fact that this temperature is increased by iron and cobalt and is lowered by other impurities; hence the net effect may be zero even when considerable amounts of impurities are present. For pure nickel the Curie temperature is approximately 353° C.

TABLE IV. RESISTIVITY OF NICKEL[135]

	Microhm -cm	at °C
Pure nickel (a)	6.141	0
....	6.844	20
....	10.327	100
Commercial nickel (d).	9.40	20

TEMPERATURE COEFFICIENT OF RESISTIVITY

[0 to 100° C]

	Per cent/° C
Pure nickel (a)	0.682
Pure nickel (a) after vacuum annealing	.692
Pure nickel (b)	.67
Pure nickel (99.97% Ni)	.681
High-purity carbonyl nickel.	.658
Carbonyl nickel directly deposited	.667
Carbonyl nickel after v acuum firing	.706
Commercial nickel (d)	.47

The magnetic saturation value is from 6,150 to 6,500 gausses, depending on the structure and purity of the nickel[40,135].

The magnetic permeability of electrolytic nickel depends to some extent on the conditions of deposition. In general, deposits produced at a high *p*H or from baths that yield hard or fine-grained deposits are less permeable magnetically than soft deposits. Bright nickel coatings from baths with organic addition agents are, however, more permeable than normal deposits. Heating at 400° C for 15 to 30 minutes causes nearly all nickel deposits to acquire about the same magnetic permeability[92].

Optical Properties

1. REFLECTIVITY. The reflecting power of a metal depends upon the wave length of light used. In the visible spectrum the reflectivity of electroplated nickel ranges from 55 to 60 per cent; the reflectivity of vacuum fused nickel is several per cent higher. This difference is inherent in the sample and is not due to polishing[33].

CONCLUSION

From this brief review of the literature it is apparent that, although many studies have been made on nickel deposits and values for their properties have been published, no systematic research has been conducted upon the relation of these properties to the conditions of deposition. Through a study of these relations it is hoped to assist the plating industry to anticipate the demands for deposits, e. g. of nickel, that will meet specific engineering needs. With such knowledge, "tailor-made" deposits may be produced.

Studies on the relations between physical properties of electrodeposits and the conditions of deposition and the composition and structure, may throw light on the mechanism of metal deposition. Such knowledge should advance progress in this field, e. g., by permitting sound predictions to be made regarding deposition of other metals.

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Over a thousand articles may be listed for nickel deposition, each giving some reference to the deposit, but to keep within the scope of this investigation, selection was necessary. Only those references which give quantitative information on the physical properties of electrolytic or pure nickel are included in this bibliography. A brief summary of the literature on the physical properties of nickel, based on this bibliography, was presented at the 1947 Convention of the American Electroplaters Society.

The references have been arranged according to years and alphabetically for each year. An index has been prepared listing the references for each property.

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Book Review

by DR. HAROLD J. READ,
Associate Professor of Metallurgy
The Pennsylvania State College

HANDBOOK OF INDUSTRIAL ELECTROPLATING by E. A. Ollard and E. B. Smith, 1947, 308 pages. The Louis Cassier Company, Ltd., Dorset House, Stamford Street, London, S. E. 1. Price, 15 shillings plus postage.

As the authors clearly state in their preface to this book, they have attempted to describe only the practical aspects of installing and maintaining a plating shop. All theory has been omitted, and the volume is not intended to be a complete textbook.

Recommended solution compositions and plating conditions are in many cases somewhat different from those commonly used in this country, and are probably not so well adapted to rapid plating and high output per plating unit.

In the discussion of nickel plating there is no information on methods of purifying the solutions or any intimation that this is a desirable operation. Nowhere was there mention of bagging nickel anodes. Aside from a brief description of two types of filtering devices, there is no material relative to the need of purification of any solution or any information on the harmful effects of certain impurities. The single page on requirements which should be met by the water used in the plating shop seems disproportionate to the importance of this factor, and no suggestions are made as to how water may be treated to improve its quality for plating work.

There are several minor points on which criticism might be offered. It would have been well, for instance, to have presented all information on the technique of heating solutions in one place instead of two. The apparatus recommended for the determination of ammonia is likely to lead to high results for lack of a proper spray trap. The paragraph defining *p*H may very well prove more confusing than helpful. The analytical methods given for zinc are not particularly satisfactory for control purposes. The very useful magnetic methods of measuring the thickness of deposits are given relatively little attention, whereas the destructive chemical dropping and jet tests are described in considerable detail.

One of the very interesting sections of the book is the glossary. Here are found tables of abbreviations, common names of chemicals, British Standards Institution abbreviations, and trade names of coatings. This material is very useful to those who have occasion to read the English literature.

This reviewer can recommend this book as a well-written addition to the bookshelf of any electroplater, especially if he is interested in knowing how other people do things.

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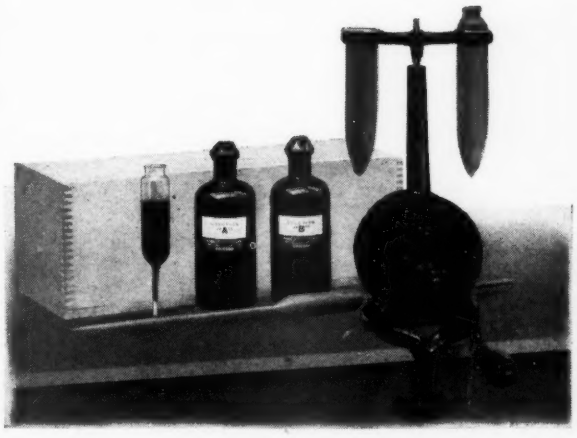

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The Question Box

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Q. 1. What is the best method for getting nickel to cover soldered joints on brass parts?

A. Use an acid dip, prior to nickel plating, of 15 to 30 per cent muriatic acid at room temperature. Adhesion of nickel to soldered joints is seldom wholly reliable. The best plating sequence where quality is the first consideration includes a copper flash before nickel plating.—B. C. CASE.

Q. 2. What should I do to prevent orange peel effects after bright nickel plating cold rolled steel parts?

A. If possible, the thickness of the bright nickel deposit should be increased. The only other methods of eliminating this objectionable defect are polishing of the base metal, buffing of the base metal with a sisal type buff using a buffing compound with considerable cutting quality, or buffing of the bright nickel deposit. —B. C. CASE.

A. Use a steel of controlled grain size so that it does not orange peel in forming, or polish the steel to remove the orange peel before bright plating.—C. L. FAUST.

Q. 3. Which is the best method for reducing chromic acid in waste water to prevent stream pollution? I have four chromium tanks, each 3 x 4 x 3 feet deep.

A. Reference is made to page 604 of the June, 1946 issue of THE MONTHLY REVIEW which describes a procedure for reducing chromic acid in waste water. The chromic acid should be kept to a minimum concentration by the use of "save rinses" that are returned to the chromium plating tank.—C. L. FAUST.

A. Full details regarding disposal of waste water from chromic acid baths are given in the literature: see M. E. Hodges, "Treatment of Plating Room Waste Water", Metal Finishing **39**, 70–71 (February 1941); C. R. Hoover and J. W. Masselli, Ind. Eng. Chem. **33**, 133–134 (1941).—In summary, the method employed involves collecting the plating room wastes in large settling or treating tanks, in some cases as large as 20,000 gallons. The *p*H is adjusted with acid to bring it below 4. Barium sulfide is then added which accomplishes several things: it reduces the hexavalent chromium to trivalent chromium which is then precipitated as chromium hydroxide, and precipitates heavy metals such as copper and nickel as sulfides; some barium chromate may also be precipitated. The *p*H after the barium sulfide addition should be above 6.4. Sometimes lime is added to raise the *p*H, and additions of ferrous sulfate are made to reduce the hexavalent chromium. The problem of disposal of plating room wastes is the subject of A. E. S. Research Project No. 10 under Prof. Barnett F. Dodge at Yale University.—W. R. MEYER.

Q. 4. What types of barrel contact are best suited for plating very light, fragile parts?

A. Contacts which exert the least possible pressure on the load and still make reasonably good electrical contact are most desirable for this application. The type of contact which has a revolving cone at each end of the cylinder has proved itself on many such applications. The well-known flexible contacts can be used in many such applications by putting a small light ball on the end of the contact rather than the usual heavy one. Button type contacts are frequently satisfactory for such applications but are not as easily removed for cleaning as the two types described above.—R. B. SALTONSTALL.

A. If articles are so light that they have a tendency to float, a three-rod contact can be used: the rods are inserted through one head of the barrel and extend into threaded sockets in the opposite end; they are arranged symmetrically in the horizontal cylinder. Dangler contacts have been used successfully in plating this type of work; either a flexible dangler coming from the heads or hairpin danglers from center rods may be used. Button contacts are satisfactory for the ordinary run of light work. If the articles are very fragile, an oblique type barrel operated at slow speed is favored.—M. B. DIGGIN.

Q. 5. How can silver be stripped from brass without attack on the base metal?

A. The best method of stripping silver from brass with no appreciable attack on the base metal involves immersing the object to be stripped in a mixture of 19 volumes of concentrated sulfuric acid and one volume of concentrated nitric acid at 180° F. If stripping is done for analytical purposes, the work is rinsed in running clean cold water. However, in production stripping, the work is rinsed in a salt solution containing about 10 per cent sodium chloride, which serves to precipitate the silver as silver chloride, which can be recovered readily inasmuch as it settles to the bottom of the tank. Following the salt dip, the work is rinsed with clean water.—The stripping solution should have a cover so that it will not be exposed to the air because if it absorbs moisture from the air it becomes diluted and will have greater attack upon the brass. The work to be stripped should *not* be wet with water before immersion in the stripper solution.—W. R. MEYER.

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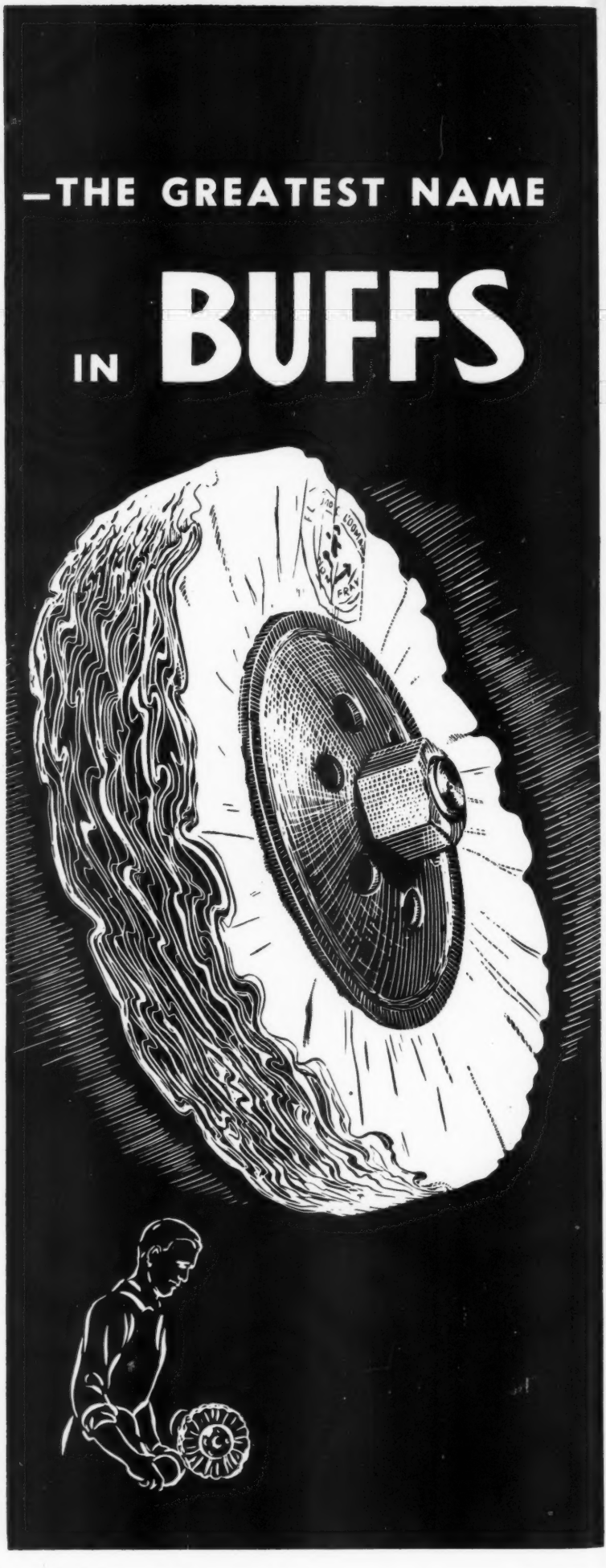

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Abstracts

For copies of original articles, turn to your Public Library for photostats or addresses of the publications in question.

Materials and Finishes for Tropical Service. C. D. Cook and C. Merritt, Jr. Materials and Methods **25,** 77–80 (May 1947).

Discusses humidity-testing procedure. Tables give results of humidity and salt-spray tests on several metals with various types of surface finishes. Another summarizes the electrolytic behavior of certain materials.

The Attack of Molten Zinc on Steel in Hot-Dip Galvanizing. Heinz Bablik. Metal Treatment **14,** 29–35 (Spring 1947).

Discusses the above subject and the structure of the coatings formed in relation to the structure of the steel. Certain analogies are found between the attack by molten zinc and by sulfuric acid. Surface decarburization is believed to be important in determining the structure of the coatings.

The Electrolytic Polishing of Metals. Part I. Electrolytic Polishing of Copper in Ortho-Phosphoric Acid. Physical Metallurgy Report No. 9. Council for Scientific and Industrial Research, East Melbourne, Australia, Serial No. A.146 (Sept. 9, 1946), 7 pp.

Gives details of the results of a study of the mechanism of the above electropolishing process.

Finishing Steel for Decorative and Protective Purposes. Reid L. Kenyon. American Iron and Steel Institute, New York, Preprint (1947), 28 pp.

Reviews developments in nonmetallic finishes, electroplated and hot-dip metallic coatings, combined metallic and nonmetallic coatings, porcelain enamels, stainless steel, and special finishes.

Practical Methods in Heavy Industrial Nickel Plating. E. J. Roehl. Metal Finishing **45,** 56–59, 71 (May 1947).

Discusses physical properties; cleaning; adhesion; deposition rate; plating baths; anti-pitting agents; metal distribution control; machining; and applications.

Metallography for the Electroplater (Concluded). Alex Blazy and J. B. Mohler. Metal Finishing **45,** 68–71 (May 1947).

Concludes illustrated description of techniques. Includes table giving procedures for the common metals and alloys.

Factors Affecting the Distribution of Electrodeposits. N. A. Tope. J. Electrodepositors' Tech. Soc. 22, 29–44 (1947). (Reprint.)

Discusses factors affecting primary current distribution: influence of surface condition; methods of

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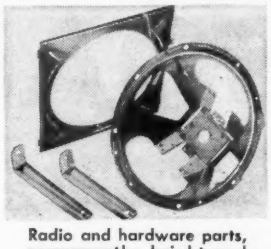

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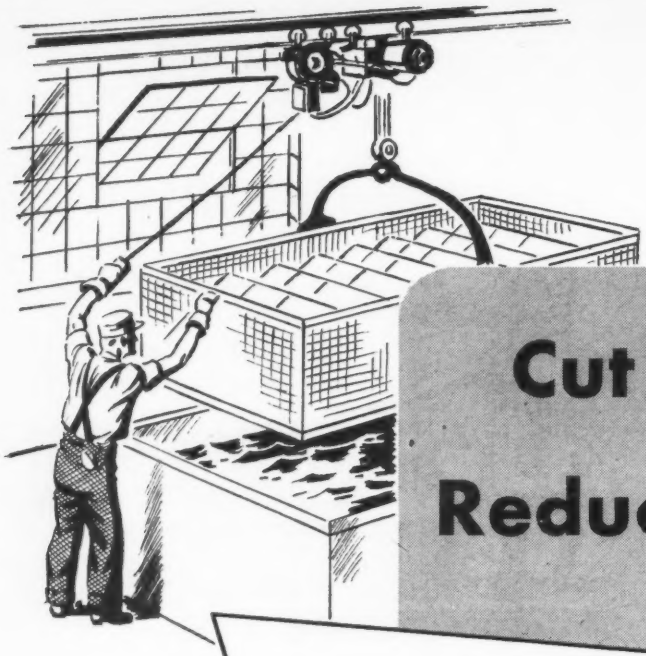

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modifying current distribution; effect of gas evolution; influence of specific conductivity of materials; influence of anode distribution; electrochemical factors concerned; effect of metal ion concentration; factors affecting deposition potentials; use of strikes; effect of addition agents and contaminants; and bright and alloy plating. 16 ref.

The Metallizing of Glass and Plastics by the Reduction of Aqueous Solutions. Patrick B. Upton. J. Electrodepositors' Tech. Soc. **22**, 45–72 (1947). (Reprint.)
Describes the more important of the older processes, together with new modifications, and attempts to collate the new methods or techniques now being employed or developed. Refers to preparation of the surface to be metallized; general considerations relating to silvering processes and their application; remarks on particular silvering processes; use of metals other than silver; and use of the metal film as a basis for electrodeposition. Summarizes in tabular form some of the processes mentioned.

Discussions. J. Electrodepositors' Tech. Soc. **21**, 265-297 (1946). (Reprint.)
Ten papers published by the Society during 1946 are discussed. They were concerned with: electrodeposition of speculum and of Sn-Zn alloys; determination of thickness of chromium deposits on nickel; electrogalvanizing of wire; electropolishing methods and applications; electroplating on aluminum; and plating-solution defects and their remedies.

The Determination of Cyanides. T. R. Haseltine. Water and Sewage Works **94**, 187–191 (May 1947).
Gives details of a search for a satisfactory method for industrial wastes and shows flow diagram for cyanide removal by treatment with alkali and chlorine. 13 ref.

Abrasion Anayslis of Protective Coatings. L. S. Barker. Light Metal Age **5**, 25 (May 1947).
Describes the technique.

Heat Testing of Aluminum Coatings. S. H. Philips. Light Metal Age **5**, 26 (May 1947).
In order to protect aluminum alloys used in super-speed aircraft from the bad effects of high temperatures caused by air friction, coatings must be investigated for their heat-absorption properties. A technique for evaluating this property is outlined.

Pressure Welding of Light Alloys Without Fusion. R. F. Tylecote. British Welding Research Association, London (January 1946), 16 pp.
Describes results of attempts to weld overlapping sheets of nine aluminum and three magnesium alloys by simultaneous application of heat and pressure at temperatures below their melting points. It was found possible to weld all the alloys to a greater or

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lesser degree. An aluminum alloy containing magnesium and silicon in the proportions of Mg_2Si, a duralumin type alloy, and an aluminum alloy containing 1½ per cent manganese, were found to give the best results. Effective cleaning of the surfaces were found to be very important.

Zinc Plating for Corrosion Resistance and Decorative Finishing. W. F. Coxon. Metal Treatment **14,** 38–40 (Spring 1947).

Outlines methods used and the future possibilities, and suggests that the process is likely to prove a serious competitor of cadmium and nickel plating.

A Method for Welding Sheet Aluminum to SAE 4140 Steel. W. F. Hess and E. F. Nippes, Jr. National Advisory Committee for Aeronautics, Washington, Wartime Report W-102 (January 1944), 37 pp.

Investigation involved the study of a large number of different metals between aluminum and steel for the purpose of securing good bonds of high strength and thermal conductivity. Silver was found to be the most satisfactory intermediate metal; it is electroplated onto the steel, then the aluminum and the silver are welded together. It was necessary also to develop special techniques for the surface preparation of the steel for electroplating and of the aluminum for welding, and for the avoidance of martensite formation in the steel during welding. The latter was accomplished by use of a high-resistance insert between the electrode and the aluminum surface. A welding machine was modified and used for welding aluminum fins to a cylinder barrel.

Reversible Overvoltage. Edgar Newberry. Trans. Faraday Soc. **40,** 127–138 (March 1947).

Experiments with an improved form of cathode-ray oscillograph indicate that the total opposition to the passage of current between electrode and electrolyte when a gas is liberated consists of two distinct parts, an irreversible and a reversible. The irreversible part is due to the electrical resistance of a film of gas of atomic thickness, completely covering the electrode surface and forming the dielectric of a high-capacity condenser; the reversible part is made up of four parts: concentration polarization, back ionization of the deposited gas, back ionization of the electrode itself, and back ionization of overvoltage compounds of the gas with the electrode metal. The latter item is said to be the only one which is really "overvoltage". Values are given for a series of metals.

Problems in Cell Design for Electrolytic Chromium. R. R. Lloyd. Engineering and Mining Journal **148,** 95–97 (July 1947).

Discusses cell design problems in connection with the process for electrowinning of chromium from low-grade domestic ores being developed in laboratories of U. S. Bureau of Mines at Boulder City, Nev.

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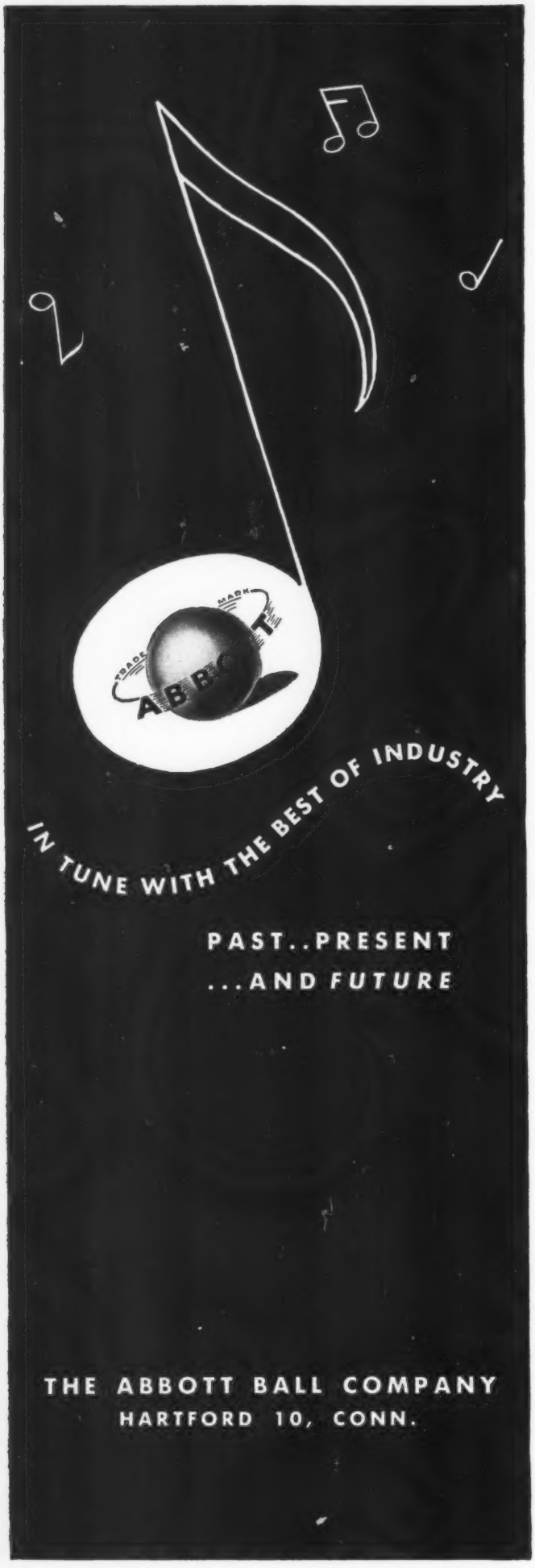

Patents

By GEORGE B. HOGABOOM
Consultant, New Britain, Conn.

No. 2,430,304, November 4, 1947—Anodizing Iron Group Metals in Lead Sulfamate Bath—E. W. Schweiker, assignor to E. I. du Pont de Nemours & Company.

This invention relates to electrodeposited coatings and is more particularly directed to the electrodeposition of black coatings containing lead oxides upon metals of the iron group anodically in a lead sulfamate solution having a *p*H of about 4.2 to 5.9, to articles having upon their surfaces black-lead oxide coatings so produced, and to compositions comprising lead oxide and sulfamic acid adapted to maintaining said lead sulfamate solutions during use at a *p*H of about from 4.2 to 5.9.

EXAMPLE. To a solution containing 150 grams per liter of sulfamic acid there was added 200 grams per liter of litharge and the solution was stirred until the litharge had all dissolved. The resulting solution had a *p*H of 5.5. In this solution well cleaned panels of steel were made the anode and electrodeposition was effected by passing a current through the solution using lead cathodes. There was thus produced upon the steel panels a black deposit which was strongly adherent, abrasion resistant, corrosion resistant, and which upon analysis was found to contain lead oxide and iron oxide.

CLAIM 1. In a process for producing coatings upon iron group metals, the step comprising electrolyzing an iron group metal anodically in a solution having a *p*H of about from 4.2 to 5.9 and containing about from 75 to 450 grams per liter of lead sulfamate.

3 claims.

No. 2,430,468, November 11, 1947—Electroplating Silver on Aluminum and Its Alloys—E. M. Julick and W. A. Mehmel, assignors to Bell Telephone Laboratories, Inc.

It is well known that metal coatings formed directly on aluminum or aluminum alloys by electroplating possess poor adherence. It has been proposed to increase this adherence by first forming an oxide coating on the aluminum base by means of anodic treatment in an acid bath and then dissolving a portion of the oxide film in an acid or alkaline bath, prior to electroplating (W. J. Travers, *Transactions of the Electrochemical Society*, vol. LXXV, 1939, p. 201; U. S. Patent 1,971,761). It has also been proposed to electroplate directly over an oxide film produced by anodizing aluminum or aluminum alloys in chromic acid or phosphoric acid solution without intermediate treatment of the oxide film (J. Fischer, U. S. Patents 1,947,981, 2,036,962 and 2,095,519).

It has been found that, when plating with silver, a far superior adherence is obtained by the method of the present invention than by any of the previously proposed methods.

CLAIM 9. The method of silver plating a predominantly aluminum body comprising subjecting said body to an alternating current potential while immersed in a 3 per cent aqueous solution of phosphoric acid maintained at a temperature between 70° F and about 75° F, maintaining the current density at between about 3.5 and 6 amperes per square foot by applying an initial voltage of about 5 volts and gradually increasing the voltage to about 50 volts as an anodic coating is formed on the body, removing the anodized body from the phosphoric acid solution and washing thoroughly with water, immersing said body, before any substantial alteration of the anode coating, as the cathode in a silverplating bath consisting of an aqueous solution of about 1.5 ounces per gallon of silver sodium cyanide and 6 ounces per gallon of sodium cyanide, and electrodepositing silver on said cathode by subjecting said cathode to a current density of about 1.5 to 2 amperes per square foot for a time sufficient to form a silver coating on said cathode of desired thickness.

9 claims.

No. 2,430,750, November 11, 1947—Method of Electroplating to Produce Fissure Net-Work Chromium Plating—T. H. Webersinn and J. Hyner, assignors to United Chromium, Incorporated.

This invention relates to methods of electrodepositing chromium in which the conditions of deposition are so correlated and controlled as to give a chromium plate which is predisposed to the formation of fissure networks and which upon etching gives mud-crack type surfaces having plateau areas which do not exceed a desired size; said surfaces being particularly suited after mechanical finishing to frictional contact with other surfaces.

EXAMPLE 1. *Chromium electrodeposition bath:*

Chromic acid (CrO_3), g/l	250
Sulfate (SO_4), g/l	2.50
(No other catalyst present)	
Temperature, ° F	140
Current density, asf	4

Etching bath:

Phosphoric acid, g/l	290
Potassium dichromate, g/l	10
Trivalent chromium (added as potassium chrome alum), g/l	2
Temperature, ° F	160
Cathode treatment (for 15 minutes), asf	0.5

Result:

Mud-crack type surface with average plateau size of approximately 1/80 inch diameter.

5 examples.

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ST. LOUIS: G. S. Robins & Co. DALLAS, TEX.: Texokana Supply Co. LOS ANGELES: Barber-Webb Co. OAKLAND: Geo. A. Kushman Co.

CLAIM 3. A method of producing articles having chromium electrodeposits thereon with a fissure network therein and firm areas within said fissure network having an average diameter of two hundredths of an inch for sustaining frictional load of moving parts bearing on said plateaus comprising electrodepositing the chromium from a chromic acid bath to a minimum thickness of one thousandth of an inch at the usual commercial current densities for the bath temperature at which the plating is done, within the range of 1 to 12 amperes per square inch, under correlated conditions of temperature and ratio of CrO_3 to SO_4 related to said average plateau diameter, etching the chromium electrodeposited as herein stated to develop a fissure network of plateaus therein of said average diameter of two hundredths of an inch to which it is predisposed, and mechanically finishing the firm plateaus to produce a smooth bearing surface with said fissure network remaining therein, the correlated conditions of temperature and CrO_3 to SO_4 ratio for electrodepositing the chromium being defined in the following table, the values of temperature and ratio intermediate to those tabulated being obtained by interpolation:

Ratio CrO_3 *to* SO_4	*Temperature* ° F
75–1	157
100–1	146
115–1	140
125–1	136
150–1	130

4 claims.

U. S. Patents Cited in Reference

Number	*Name*	*Date*
1,802,463	Fink	Apr. 28, 1931
2,048,578	Van der Horst	July 21, 1936
2,314,604	Van der Horst	Mar. 23, 1943
2,412,698	Van der Horst	Dec. 17, 1946

No. 2,431,065, November 18, 1947—Continuous Wire and Strip Electroprocessing Machine—C. G. Miller, assignor to The Meaker Company, Chicago, Ill.

This invention relates generally to an apparatus for electroprocessing of metal, and more particularly to a machine for electrochemically cleaning and electrogalvanizing continuously moving articles and materials such as wire. The invention disclosed and claimed in this application is an improvement over my copending application Serial No. 87,850, filed June 29, 1936.

The apparatus in this invention is especially adapted for electrogalvanizing round or flat wire, strip steel, metal ribbons, cables, tubing, and the like.

CLAIM 5. An apparatus for electrolytic mechanical processing of a moving wire, including a tank adapted to contain electrolyte and means for guiding the wire substantially horizontally through said tank below the level of the electrolyte, the combination therewith of an electric contactor rod pivoted about a point above said wire, the end of said rod being in contact with

(*Continued on page 87*)

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E—3. **New Selenium Rectifier**—The Rapid Electric Company, 2847 Middletown Road, Bronx 61, N. Y., has recently announced its Model TC 1575. It is claimed to be the only selenium rectifier that combines the following features:

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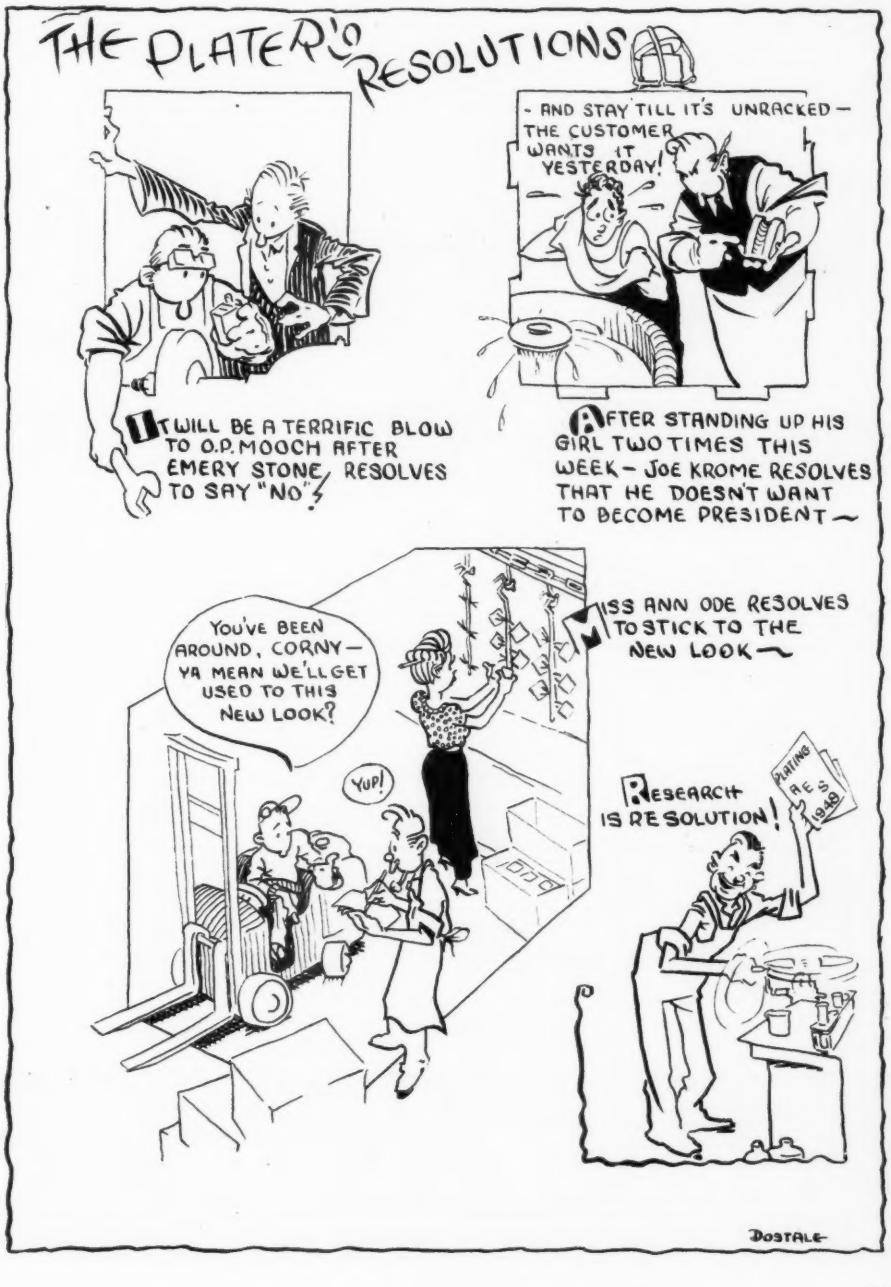
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E—6. **Clamp for Handling Drums in the Upright Position**—For safe handling of drums which must be moved singly or upright to avoid spilling, a recently perfected clamping device is easily adapted to any of the Clark Tructractor fork truck models.

The clamp is self-adjusting for diameters 21½ to 24 inches and employs a star cam permitting the operator to release the drum without dismounting. Clamping over the chime, the device grips securely throughout transportation and carries up to 700 pounds, and it may be used on fork trucks equipped with crane, swinging boom, or special fork extension attachments. The manufacturer is Clark Tructractor Division of Clark Equipment Company, Battle Creek 33, Mich. For additional information, use Reader Service Card.

E—7. **"Activated" Silver Anodes**—The combination of high purity silver and special processing control has resulted in the production by The American Platinum Works, 235 N. J. R. R. Avenue, Newark 5, N. J., of a new type of silver anode for general use by the plating industry.

APW "Activated" Silver Anodes dissolve cleanly and evenly and because of their high purity there is no discoloration of the surface or sedimentation in the plating tanks. The result is a minimum of scrap, easier and better control of plating bath and cleaner, brighter, better plated products, it is claimed.

These improved high purity rolled silver anodes are extensively used by the trade and are available without premium. APW silver cyanide is also supplied to the plating industry and recommended for use with "Activated" Anodes. For additional information, use Reader Service Card.

E—8. **Lead Anodes Equipped with Cast Copper Hook**—Development of cast copper anode hooks, which are claimed to be the first ever used, is announced by Division Lead Company. 836 W. Kinzie Street, Chicago 22, Ill.

Used on Divco 71-Point Lead Anodes, the cast copper hooks are said to double the current carrying capacity and further increase the overall efficiency of the anode.

The cast design retains its special shape which facilitates handling as well as assures efficient conductance and secure bonding to the anode body. For additional information, use Reader Service Card.

E—9. **New Barrel Lifter**—Merrill Brothers, 56-02 Arnold Avenue, Maspeth, N. Y., now manufactures a "Twin Barrel Lifter" whereby steel barrels can be hoisted straight up instead of being lifted at an angle by gripping and raising it from one side.

The unit is a device consisting of a cross arm of the width of the standard barrel with a Volz Clamp attached to both ends of the arm. The center of the cross bar is provided with a ring through which the hook of the hoist or other lifting media is attached. The clamps can be instantaneously attached and detached to and from the barrel. The heavier the load, the tighter is the grip of the Volz Clamp.

It is sold through leading hardware jobbers and mill supply houses. For additional information, use Reader Service Card.

E—10. **Prefabricated Plating Plants and Units**—The Unit Process Assemblies, Inc., 75 E. 4th Street, New York 3, N. Y., announces that it now manufactures complete plants or units for all types of plating, electroforming, anodizing and electropolishing.

The plant units include all tanks, rectifiers, and electrical, water, drain and exhaust lines shipped knocked down and requiring only simple assembly with screw driver and wrench and connection to main utility lines. They are available in

TODAY'S BEST BUY
for Setting Up POLISHING WHEELS AND BELTS
GRIPMASTER PATENTED POLISHING WHEEL CEMENT

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GRIPMASTER BOOSTS POLISHERS' PRODUCTION AN AVERAGE OF 47% MORE PIECES PER HEAD!

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GRIPMASTER MEETS EVERY NEED
Gives astounding results on all metals—ferrous and non-ferrous. Ideal for plastics, too!

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P-1

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a wide variety of standard models of different capacities but may also be custom built at no extra cost. Compact instruction and layouts are said to reduce floor space requirements materially. For additional information, use Reader Service Card.

E—11. **New Grades of Acme Liquid Tripoli**— Four grades of a new liquid tripoli composition have been perfected by Hanson-Van Winkle-Munning Company, Matawan, N. J., and designated as Acme Nos. 2-L-70, 2-L-75, 2-L-77 and 2-L-79. The characteristics of these grades are given below:

Grade	*Characteristics*
2-L-70	Double duty with superior color
2-L-75	Medium cut with good color
2-L-77	Good cutting with medium color
2-L-79	Heavy cut with medium color

These compounds have been tested in production for a number of months and each grade has demonstrated marked efficiency. They will not cause soggy or clogged buffs when properly applied, it is claimed.

Acme liquid tripoli may be used with any approved type of spray equipment; however, Eclipse spray equipment is recommended. H-VW-M has entered into an agreement with Eclipse Air Brush Company for the distribution of special equipment for the application of these new liquid tripoli compositions, and is prepared to supply complete installations and service. For additional information, use Reader Service Card.

E—12. **Buffing Compounds**—The new Hydro-Buff "500" series of buffing compounds recently announced to the finishing trade by the Hydro Chemical Company, East Hartford, Conn., is reported to offer unusual possibilities for decreasing buffing operational time on both ferrous and nonferrous metals. It is claimed by the manufacturer that by using Hydro-Buff buffing compounds, cleaning time of pieces is cut to 30–45 seconds.

The "500" series of compounds constitute no fire hazard since they are noninflammable and are soluble in all proportions in chlorinated hydrocarbons. Hydro-Buff is suited for plants equipped for vapor-phase degreasing operations and is also readily removed in the water-phase cleaning cycle. The retention of Hydro-Buff on buffing wheels is good; it cuts and colors in the same operation, eliminating the need for rouge; and the film remaining on the piece, before cleaning, will protect against oxidation and staining for long periods of time. For additional information, use Reader Service Card.

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For Electroplating
Anodizing
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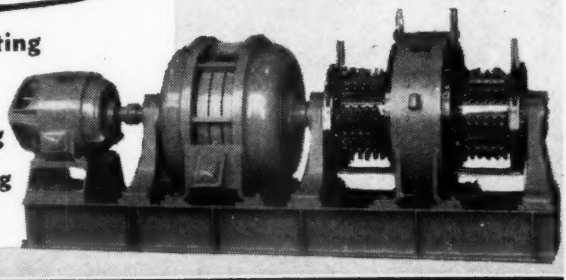
There's a Columbia M-G Set available for your needs, whether you have a small plating bath or a large continuous strip plating line. Capacities up to 20,000 Amperes; 6 Volts and up. Dependable, performance proved, for many years. Your inquiries solicited.



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IT'S HERE
RACK COATING

with 100% SOLIDS

IT'S READY for you now—Coating 218—the last word in rack coatings if you want a job that lasts, saves money and is quickly done. Here's why:

NO THINNERS! You get all *working* material in Coating 218. Nothing to evaporate, nothing to replace, no fire hazard.

FEWER COATS! Only *one* main coat is required over prime and "tie" coat. It goes on *smoothly* overall—in a coating that's far thicker than *eight* coats of solvent types!

QUICKLY APPLIED! Racks are ready in less than ¼ of the time ordinarily needed. You do the job in about 2 hours with Coating 218.

SUPER TOUGH! Elastic Unichrome Coating 218 won't tear or chip, blister or lift. This scuff-proof jacket stays sleek and smooth through toughest plating cycles!

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Duluth Buff Company has resolved to continue manufacturing the best quality buffs that fine sheeting material and experienced craftsmanship can produce.

There is only one Duluth Buff Company and it has one standard for all types of buffs, but particularly does Duluth do best all around with the Square Sewed Buffs.

Duluth Square Sewed Buffs offer varied sizes of squares, from ¼″ to 4″. The square sewings afford substantial savings in wear. They also create more economical use of the abrasives that are preserved in the square sewed pockets.

Duluth Square Sewed Buffs are furnished in the various grades that are available in other full disc and pieced buffs.

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CHICAGO 16, ILLINOIS

New Literature

L—1. Synthetic Detergents—A 32-page booklet (No. A-13) published by the Miranol Chemical Company, Inc., 2 Ford Avenue, Milltown, N. J., describes 10 "Miranol" detergents and wetting agents used in making a huge variety of different products. They are said to meet the requirements for most applications of synthetic detergents. For your copy, use Reader Service Card.

L—2. Water Softeners—A 20-page illustrated bulletin No. 4345 describes and illustrates Cochrane Green Sand Zeolite water softeners for numerous industrial applications. Full specifications of several styles of equipment available are given, and photographs and diagrams clarify points made in the text. This bulletin is issued by Cochrane Corporation, 17th Street and Allegheny Avenue, Philadelphia 32, Pa. For your copy, use Reader Service Card.

L—3. Corrosion-Resistant Y and Angle Valves—A new bulletin released by The Duriron Company, Inc., of Dayton, Ohio, describes Durco corrosion-resisting, Series 35 Y valves and series 36 Angle valves and shows their internal construction by means of cutaway views. These illustrations bring out every construction detail and show, in color, exactly which parts of the valve are made of a special corrosion-defeating Durco alloy. Features are listed and a brief explanation of the type of service for which the valves are best suited is given. The bulletin provides complete dimension data on the various sizes and includes an illustrated parts list.

The folder also tells how the valves can be equipped with air operated diaphragm motors for automatic regulation of the flow of corrosive solutions.

Copies of bulletin 615 are free upon request. For your copy, use Reader Service Card.

L—4. Prepaint Treatment for Metal Products—How one prominent manufacturer obtains durable finishes and added attractiveness for its line of metal furniture, is described in a special feature article, "Conditioning Metal Furniture for Good Paint Adhesion", appearing in the September-October issue of Oakite News Service, bi-monthly house publication of Oakite Products, Inc., New York. For your copy, use Reader Service Card.

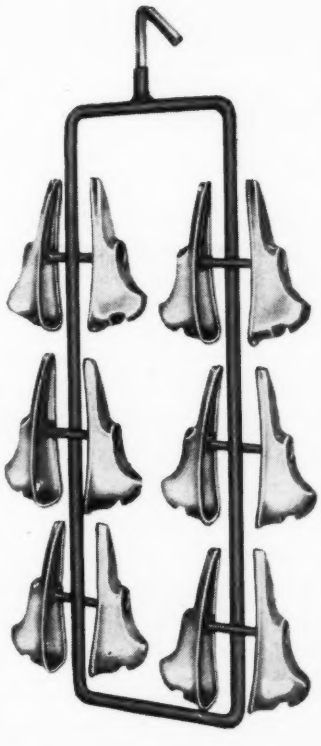
L—5. Improved Adhesive for Polishing Wheels—The usual deficiencies of organic glue are said to be overcome when Klinch Grain Cement and Thinner are used for setting up polishing wheels, according to Hanson-Van Winkle-Munning Company, Matawan, N. J. Klinch is an improved cold cement adhesive carefully compounded to provide a firm grip on the abrasive grain—yet flexible enough to assure satisfactory results over a wide range of uses. It has been used in the field for a number of months with complete success. For grit sizes coarser than No. 180, Klinch is used as received. For finer grit sizes, its consistency should be reduced by adding Klinch Grain Cement Thinner. Correct mixture for each job can best be determined experimentally, as conditions vary in all shops.

Klinch Grain Cement should be used cold, and stirred thoroughly before applying. For best results, wheels, belts or discs must be cleaned and dried—removing all dirt, oil, grease or glue with a pumice stone or other means.

Standard packaging of both Cement and Thinner is in 1-gallon cans, 5-gallon cans, and 55-gallon drums. Directions appear on every container. Details are described fully in Bulletin W-102. For your copy, use Reader Service Card.

L—6. Full Automatic Electroplating Conveyors—A 22-page profusely illustrated catalog, Bulletin FA-103 gives complete descriptions and data on all types of full automatic plating conveyors, including elevator and straight line types, manufactured by Hanson-Van Winkle-

ONE COAT PASTE INSULATION for PRODUCTION RACKS



Now in production. BUNATOL NO. 1000 Paste Insulation for plating racks. 100% solids. Not inflammable. No evaporation loss. No waste.

•

Tremendous adhesion to any metal. Low viscosity-free dipping. Save time; insulate rack complete 60 to 70 minutes.

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Single baked-on coat makes heavy smcoth insulation which lasts for months. Lowest price. Highest quality.

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Investigate. Write for complete informatien and prices.

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TOLEDO 7, OHIO

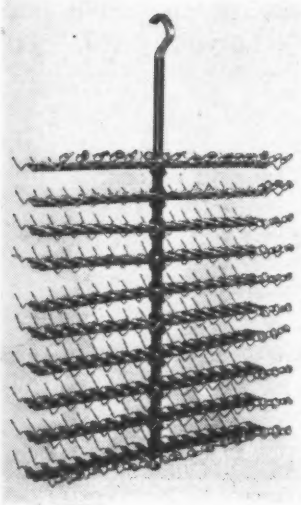
BUNATOL

Behind our racks...

• **Part of the engineering department.** (Top)

• **Modern, completely equipped tool room.** (Bottom Left)

• **Assembling racks in our modern plant.** (Bottom Right)



WHEN it comes to plating racks, the inevitable choice of electroplaters is Standard. Here's why!

Behind our racks are more than 11 years of research and experience in the plating rack business. Standard is the largest exclusive manufacturer of plating racks in the world. We know racks.

Our modern fully-equipped plant is completely devoted to the design and manufacture of racks. Here modern tools, up-to-date methods, advanced techniques serve the electroplating industry.

An excellent example of the improvements developed by Standard is Stand-It-All Insulation. This flexible insulation permanently bonded to the rack prevents plating up of the rack, saves current, saves plating material, saves the rack. Stand-It-All is typical of Standard's ability to build a better rack.

Whatever your plating problem or need, our entire organization is at your service.

STANDARD
PLATING RACK COMPANY

"What's in a name?"

1913-1925 NORTH PAULINA STREET, CHICAGO 22, ILLINOIS

Munning Company, Matawan, N. J. Many typical custom built conveyor systems are shown and various features considered. Assembly drawings of Elevator Type and Munning Type Conveyors are also included. For your copy, use Reader Service Card.

L—7. Thermocouple and Pyrometer Accessories—A new Bulletin, No. P1235, covering themrocouples, protection tubes, and pyrometer accessories, has been published by The Bristol Company, Waterbury 91, Conn. The bulletin gives detailed drawings, complete information, and prices covering the accessories for pyrometers, which the company carries in stock for immediate shipment at its main factory in Waterbury and its branch factories in Akron, Chicago, and San Francisco. In addition, it contains a chart and valuable engineering data on selecting the right thermocouple and protection tube. For your copy, use Reader Service Card.

Directory of Commercial and College Laboratories—A complete listing of commercial and university testing and research laboratories throughout country, together with indications of the type of commodities tested, has been compiled by the National Bureau of Standards. This pamphlet, NBS Miscellaneous Publication M187 entitled "Directory of Commercial and College Laboraties," may be obtained from the Superintendent of Documents, Washington 25, D. C., at 30 cents per copy.

Printed Circuit Techniques—In response to an unprecedented demand for technical information on printing electronic circuits, the National Bureau of Standards has just published the first comprehensive treatment of this subject entitled "Printed Circuit Techniques", by Drs. Cledo Brunetti and R. W. Curtis. The booklet consists of 10 chapters totaling 43 large, two-column pages and is adequately illustrated.

The methods of applying wiring and circuit components directly to an insulated surface, thus combining ruggedness with a high degree of miniaturization, are presented under the topics: Painting, Spraying, Chemical Deposition, Vacuum Processes, Die-Stamping, and Dusting. Performance and application details as well as precautions and limitations are discussed.

By means of the printing process the conventional electronic circuit—characterized by a maze of wires, resistors, inductors, and condensers—is replaced by a compact circuit printed on a small flat plate.

This NBS Circular 468 is now available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at 25 cents per copy.

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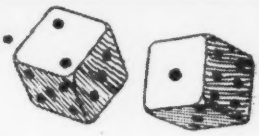

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DOUBLE - HEADER COMPOUNDS IN SIZES 150-180-220-240- 320

. . . Sure of the right compound for the right material. Sure, too, of the uniform, dependable quality built into every Harrison product for over 25 years.

For faster cutting, increased production, greater economy, specify Harrison 4-A Products. We will be glad to advise you on special problems and furnish samples of compounds that will meet your needs.

HARRISON & CO., INC. Dept. 1 **HAVERHILL, MASS.**

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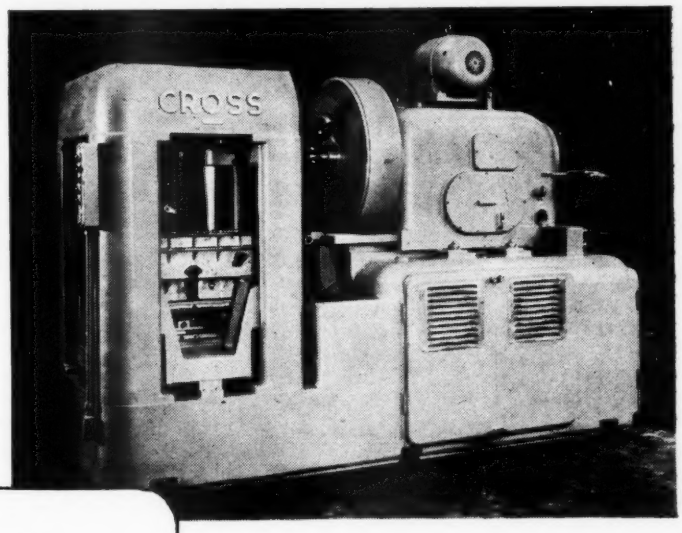

A Fine Protective FINISH for High Production Tools

Specialized finish of high quality is required to protect the surfaces of high-production automatic tools . . . and specialized finish of high quality is what Egyptian supplies, always.

Egyptian offers the right finish for every requirement. If your needs are for standard finish, or for something very special, you can safely rely on Egyptian. Inquiry is invited.

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For efficient, economical bright zinc plating

1. DU PONT "ZIN-O-LYTE" Zinc Plating

- the only process yielding brilliant, blue-white zinc deposits direct from the bath *without bright dipping!*
- high operating efficiency at both high and low current densities.
- baths easily made up from prepared salts.
- suitable for all types of zinc plating, particularly barrel plating.
- satisfactory for use with almost all types of ferrous metals.

2. DU PONT "DUROBRITE" Zinc Plating

- easily produces bright, lustrous deposits of pure zinc on steel surfaces of almost any size or shape!
- low in cost.
- bath made up easily with standard chemicals.
- easy to operate and control—gives good results under a wide range of operating conditions.
- rapid rate of deposition with high allowable current density.

Ask your Du Pont technical representative to give you complete details on how these Du Pont Zinc Plating Processes can save you time, trouble and cost! Or write to the Electroplating Division, E. I. du Pont de Nemours & Co. (Inc.), Wilmington 98, Delaware.

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BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

FOR FURTHER INFORMATION, USE READER SERVICE CARD; INDICATE A 51.

Personals

Thomas G. Digges has been appointed chief of the Thermal Metallurgy Section of the National Bureau of Standards, according to an announcement by Dr. E. U. Condon, Director of the Bureau. He succeeds **D. J. McAdam,** who has been chief of the section since 1930. Dr. McAdam retired on August 31, 1947.

Goss

Ed Goss has been appointed to the sales staff of Wagner Brothers, Inc., manufacturers and suppliers of metal finishing materials and equipment, since the company's designation as Eastern Michigan distributors for J. C. Miller buffing compounds.

Mr. Goss will handle sales of the J. C. Miller compounds and buffs, grain, belts and other abrasive products distributed by the firm. Well known in metal finishing circles, Ed Goss has a record of twelve years' sales and production experience in the field of polishing and buffing materials.

W. G. Sheane has recently been retained by the Zapon Division of the Atlas Powder Company in keeping with its plans to augment technical staffs and increase plant facilities.

Mr. Sheane is perhaps best known in the finishing industry as a former editor of "Organic Finishing" magazine. Prior to serving in that capacity he was with the American Can Company, New York City, as a chemical engineer, and still earlier with General Electric Company as a finishing engineer.

Mr. Sheane is a graduate of Rensselaer Polytechnic Institute and Carnegie Institute of Technology. He is an active member of the American Institute of Chemical Engineers, American Chemical Society, and American Electroplaters' Society.

Samuel Spring, formerly a research specialist for the Federal Government, has been appointed to the research and development staff of the Pennsylvania Salt Manufacturing Company. He will have charge of the inorganic research group at Pennsalt's Whitemarsh Research Laboratories.

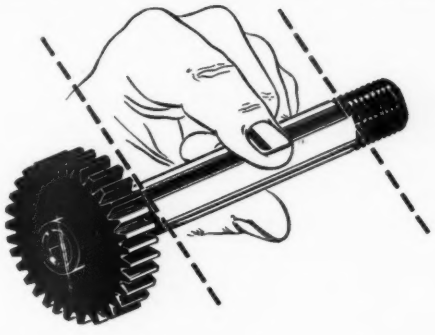
Mr. Spring, a native of New York City, and a graduate of the College of the City of New York, received his master's degree at Columbia University. For two years he served on the faculty of City College of New York and later became associated with Frankford Arsenal where he supervised research on metal cleaners and metal-working lubricants for the last seven years.

Ernest L. Gartner, manager of the Metal and Ore Division of the du Pont Company's Grasselli Chemicals Department, retired December 1 at the age of sixty-seven, after forty-three years with the company.

Mr. Gartner is an authority on zinc and other metals. During the war he was a member of the War Production Board's advisory committees on zinc and cadmium, with headquarters in Washington.

Mr. Gartner entered the employ of the Grasselli Chemical Company at Cleveland in November, 1904, and eventually became division manager in charge of zinc sales in the Cleveland Division. The du Pont Company purchased the Grasselli Company in 1928, and it was operated as a subsidiary until 1936 when it became a department of the du Pont Company.

UNICHROME Stop-Off Compounds



help you do the fastest job on complicated shapes

DIPPED ON—these easily melted, waxlike materials speed production of your work with sharp edges or complex shapes. Coatings withstand severe plating solutions and cleaners; won't contaminate the bath.

HARDEN AT ONCE—so coatings can be built up to any thickness desired on the double-quick.

EASILY REMOVED—by heating the work or immersing it in boiling water, depending on compound used. Melted compound can be reclaimed, so you save money as well as time.

Stop-Off 311 (Black)—For toughest cycles, including high temperature baths, boiling cleaners. Won't soften below 245F. Remove by heating or by solvent.

Stop-Off 314 (Brown)—For moderate temperatures. Won't soften below 160F. Remove by immersing in boiling water.

Stop-Off 315 (Brown)—Doesn't soften below 180F. May also be used to adjust working range of 314. Remove with boiling water.

UNICHROME

Trade Mark Reg. U. S. Pat. Off.

STOP-OFF COMPOUNDS—Products of

UNITED CHROMIUM, INCORPORATED • 51 E. 42nd St., New York 17, N.Y.

Detroit 7, Mich. • Waterbury 90, Conn. • Chicago 4, Ill. • Dayton 2, Ohio • Los Angeles 11, Cal.

FOR FURTHER INFORMATION, USE READER SERVICE CARD; INDICATE A 52.

YOU know what you want in a rack coating: ease of application, long life with a minimum of re-coating, resistance to treeing, resistance to salt accumulation, and certainty that nothing in the coating will contaminate your solutions.

Well, U. S. Stoneware's Rack Coating 266 fills the bill. *Ease of Application:* An air dry dip coating that requires only 3-4 dips to build up a thickness of 1/16". *Long Life:* Electroplaters tell us that Coating 266 is standing up longer than any coating they have ever used. *Resistance to Treeing:* The basic resins used in Coating 266 have even greater electrical resistivity than the best rubber. *Resistance to Salts Accumulation:* The smooth, hard-to-wet, non-porous surface of Coating 266 refuses to let salts accumulation get started. *Freedom from Contamination:* Coating 266 is made from Tygon plastics whose non-toxic, inert properties have made it popular in laboratories, hospitals, food and beverage plants.

●

If you aren't using Coating 266 place a trial order with your dealer today. You'll like it.

●

U. S. STONEWARE
Akron 9, Ohio

AMERICAN ELECTROPLATERS' SOCIETY NEWS

CONSTITUTION REVISION

The Constitution Revision Committee has placed several copies of the proposed revision in the hands of each Branch. This revision represents the thoughts of the majority as presented to the Committee. The new Constitution and By-Laws are fundamentally the same as the old ones, but have been streamlined and made more efficient. Duplications have been eliminated and new functions added where necessary.

The Committee has spent considerable time in preparing the draft now in the Branches' hands. Please look it over immediately and let us have your constructive criticism or your approval. Bear in mind the fact that this is your Society; the Constitution and By-Laws should be of your own choosing because you will be expected to live by them in all A. E. S. functions.

All changes recommended by the general membership should be made this Winter rather than cause waste of time at the next Convention at Atlantic City. Please make every effort to get all information to the Committee member serving your Branch before February 1, giving us ample time to make corrections and changes before March 1, the final printing deadline for publication in the April and May issues of our monthly journal—PLATING.

The Constitution Revision Committee:

C. NIXON
F. MACSTOKER
F. KELLER
C. KELLY
A. LOGOZZO, *Chairman*
M. GLOVER, *Tech. Proofreader*

A.E.S. PUBLICITY COMMITTEE

President Huston announces that Mr. D. X. Clarin, Metropolitan New York Division Manager of Oakite Products, Inc., has accepted the chairmanship of the Publicity Committee. He will fill the vacancy created by the resignation of Past President Frank Savage.

Past President Frederick Fulforth, and Messrs. Harold Faint and L. A. Critchfield will continue as members of the committee.

INFLATION

A. E. S. members will be interested to know that other societies have had the same difficulties with their finances as the A. E. S. and have had to resort to the same measures.

American Society for Testing Materials, we are informed, has just raised the annual dues for its several classes of membership. The vote was 15 to 1 in favor of the change, a splendid indication of the value that A. S. T. M. members put on their society.

A. E. S. EMBLEMS

Membership pins and buttons, Branch Past-President's buttons, and A. E. S. Past-President's but-tons are now available.

The price is $1.20 each.

Get yours now, through your Branch Secretary or direct from American Electroplaters' Society, P. O. Box 168, Jenkintown, Pa.

Patents

(*Continued from page 73*)

said wire, and including a covering of insulating material loosely mounted on said rod and having a grooved lower end straddling said wire, the lower end of said rod being exposed in the groove to contact the wire, the upper end of said rod being connected to a source of electric power, and the point of contact with said wire being vertically offset from the pivot point so that a gravitational force yieldingly presses said rod against the wire, said covering of insulating material having means connecting the same to said rod, said last named means including means for allowing some but preventing unlimited sliding movement of said covering on said rod.

5 claims, 7 figures; 23 U. S. patents and 5 foreign patents cited in reference.

NEW A. E. S. RESEARCH REPORT Serial No. 5

Dr. Thon's investigation of

Porosity of Electrodeposited Metals

40 pages—80 cents
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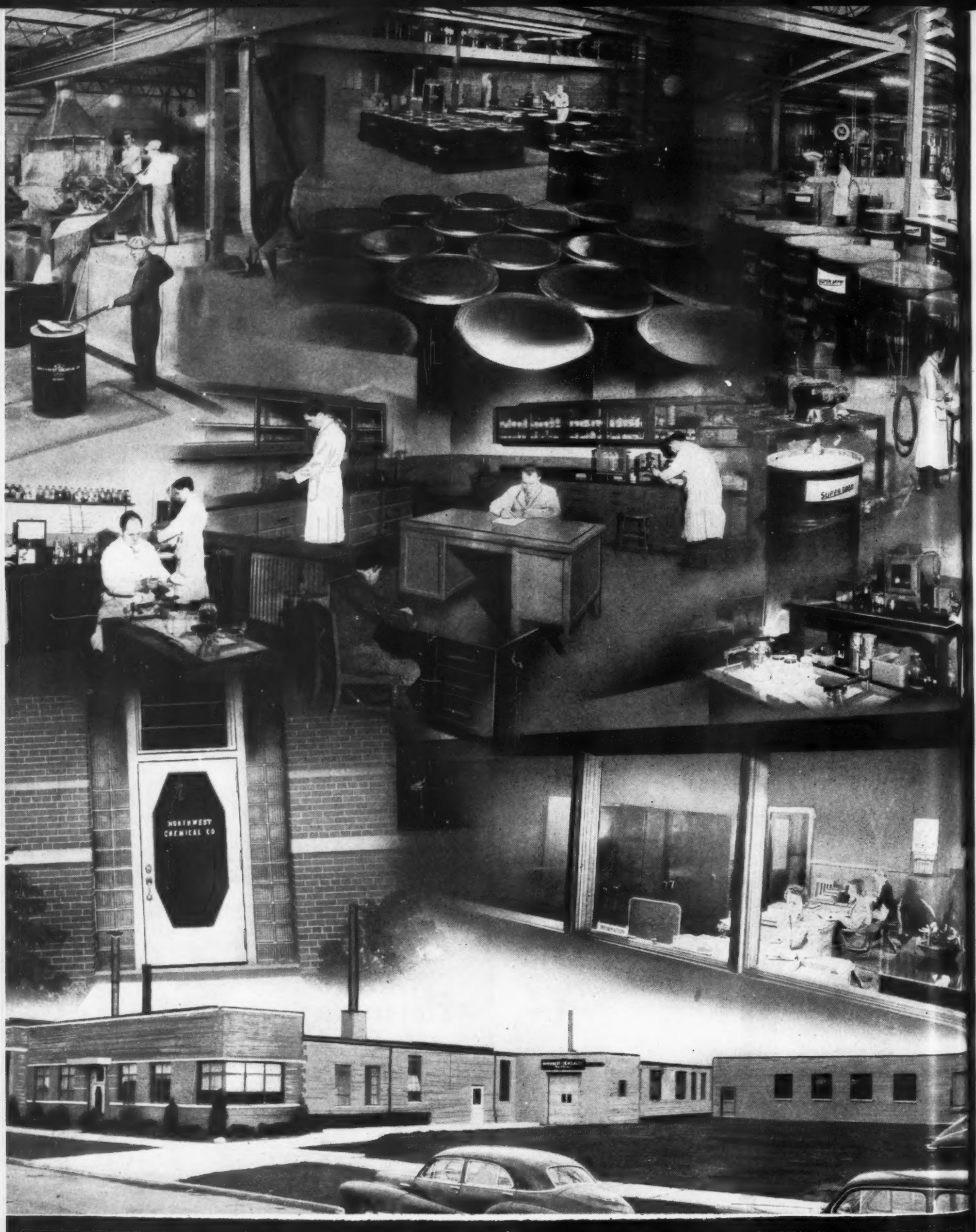

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of the American Electroplaters' Society

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COLUMBUS BRANCH: Stephen E. Timmons

DETROIT BRANCH: R. W. Pflug, A. B. Wilson

INDIANAPOLIS BRANCH: Donald L. Patrick

(Continued on page 91)

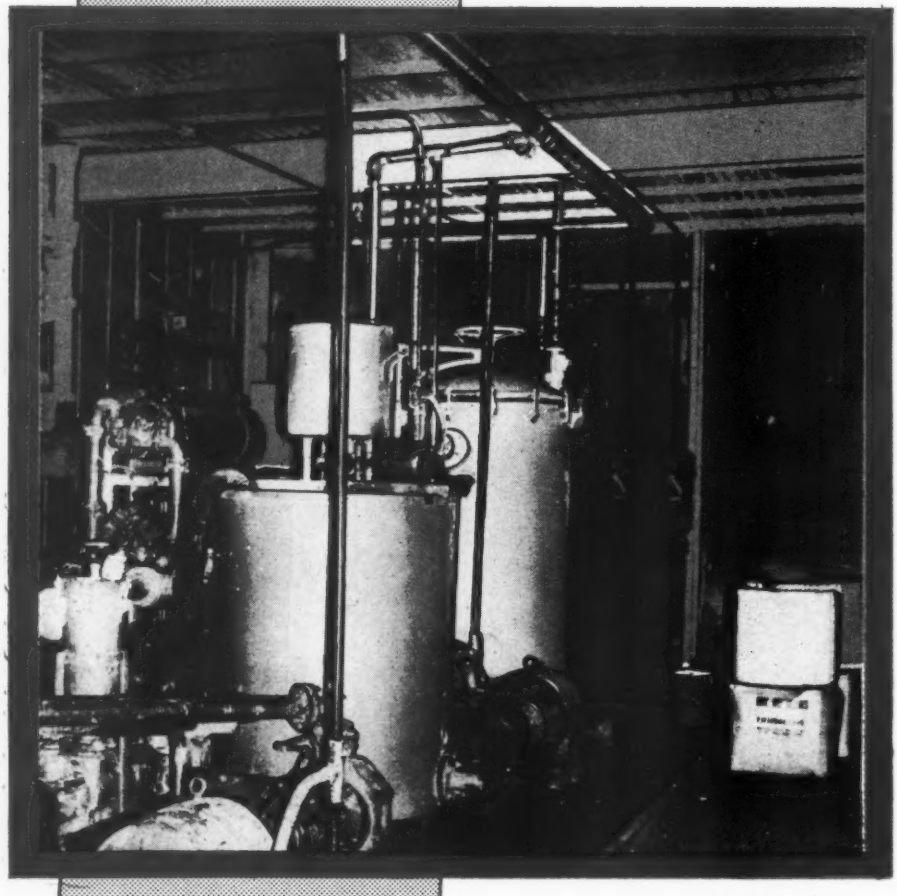
BRANCH	Membership May 1, 1947	New Members	Net Change in Membership	Per Cent Net Change
FIRST GROUP				
LOS ANGELES	198	30	+24	+12.1
BOSTON	157	21	+17½	+10.5
CHICAGO	410	39	+33	+ 8.0
BRIDGEPORT	147	16	+11	+ 7.5
HARTFORD	141	11	+ 8½	+ 6.0
PHILADELPHIA	218	18	+ 7½	+ 3.4
TORONTO	144	10	+ 4½	+ 3.1
CLEVELAND	192	13	+ 5½	+ 2.9
GRAND RAPIDS	136	29	+ 2½	+ 1.8
WATERBURY	126	3	+ ½	+ 0.4
NEW YORK	259	17	+ ½	+ 0.2
NEWARK	257	22	− 1	− 0.4
DETROIT	423	42	− 9½	− 2.2
SECOND GROUP				
PITTSBURGH	126	22	+16½	+13.1
ROCHESTER	88	5	+ 6	+ 6.8
ST. LOUIS	96	5	+ 5	+ 5.2
SAN FRANCISCO	77	6	+ 3½	+ 4.5
TWIN CITY	89	5	+ 4	+ 4.5
ST. JOSEPH VALLEY	89	10	+ 3½	+ 3.9
MILWAUKEE	124	8	+ 1	+ 0.8
NEW HAVEN	114	10	.....	.....
BALTIMORE-WASH.	119	10	.....	.....
DAYTON	95	4	− 1½	− 1.6
BUFFALO	98	6	− 3½	− 3.6
PROV.-ATTLEBORO	126	19	− 5	− 4.0
INDIANAPOLIS	103	22	− 4½	− 4.4
THIRD GROUP				
ADELAIDE	49	14	+13	+26.5
TOLEDO	55	20	+14	+25.5
SYDNEY	78	17	+12	+15.4
CINCINNATI	52	7	+ 5	+ 9.6
LANCASTER	38	6	+ 3	+ 7.9
SPRINGFIELD	73	6	+ 4	+ 5.5
COLUMBUS	35	6	+ 1½	+ 4.3
SYRACUSE	73	3	+ 1½	+ 2.1
MELBOURNE	61	..	.....	.....
ROCKFORD	64	4	− 2	− 3.1
MONTREAL	60	1	− 2	− 3.3
SOUTHEASTERN	43	4	− 1½	− 3.5
JACKSON-LANSING	65	4	− 7½	−11.5
TOTAL A. E. S.	4,898	495	+175	+ 3.6

Membership, December 10, 1947 5,073

Quality Plating

AT LOWER COST!

To obtain quality plating on a production basis requires plating solutions that are clean. The presence of impurities in solutions means an increase in the amount of rejects. Proper filtration is the economical way to increase your production and keep it on a quality basis. Plating shops that operate on a large scale day in and day out, know the value of keeping their solutions free of impurities. That is why Industrial Filters are the first choice of platers who are quality minded.



At left — Industrial filter system on brite nickel installation in a large automotive plant.

This arrangement consists of filter, pumping unit, primer-strainer unit, mixing tank, control valves, fittings and piping.

These features facilitate the convenient use of filter aids and purifying agents, making it an ideal continuous filtration system, and equally as effective for intermittent filtering. Systems are provided for either acid or alkaline solutions.

For 20 years "Industrial" has been building filters for plating solutions that have enjoyed an outstanding reputation for dependability, low upkeep cost, long life and bed rock operating economy. That is why so many platers say "I prefer the Industrial way."

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TOLEDO BRANCH: William Hunlock, Robert Milligan, Paul Miller, Howard J. Schwab

WATERBURY BRANCH: Edward S. Richards

Resignations

BUFFALO BRANCH: A. Holt

DETROIT BRANCH: H. C. Duggan

GRAND RAPIDS BRANCH: Frank H. Joyce

HARTFORD BRANCH: Ruth L. Payne

NEW HAVEN BRANCH: George C. Gerner, Clinton S. Goodwin, Kenneth Levenseler, William G. Yokel, Charles Robbinette, Edward H. Leonard

PROVIDENCE-ATTLEBORO BRANCH: H. W. Spencer

SYDNEY BRANCH: R. N. Whale

TOLEDO BRANCH: Roger Lindsay

TORONTO BRANCH: A. P. Monro

Deaths

DETROIT BRANCH: Harry M. Blum, Henry Frank

GRAND RAPIDS BRANCH: Axel Rickson

NEW HAVEN BRANCH: Joseph T. Sheridan, George Kish, Thomas Brosnan

---

ADDRESS DESIRED

Anyone who is familiar with the present address of Mr. Edward S. Richards, formerly with the Verichrome Company, Walsall, England, is kindly asked to communicate it to the Executive Secretary, Box 168, Jenkintown, Pa. Thanks!

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★ Gear or sheave drive.

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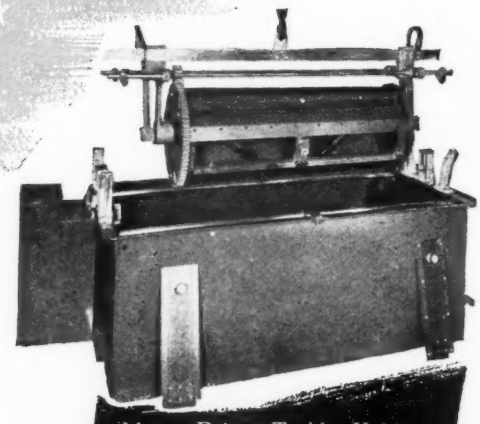

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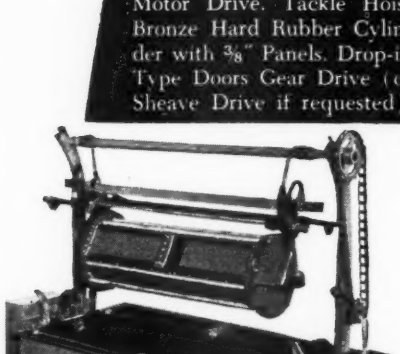

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LOCAL BRANCHES

ADELAIDE, AUSTRALIA. Acting Secretary, G. N. Dixon, G. P. O. Box 428D, Adelaide, Australia.

BALTIMORE-WASHINGTON meets first Tuesday of October, December, February and April at National Bureau of Standards, Washington, D. C., and of November, January, March and May at American Hammered Piston Ring Company, Baltimore, Md. Secretary, Grace Riddell, Chemistry Division, National Bureau of Standards, Washington 25, D. C.

BOSTON meets first Thursday of each month in Hotel Statler. Secretary, Dr. George P. Swift, 53 Galen Street, Watertown 72, Mass.

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CHICAGO meets second Friday of each month at 8 P. M. in Atlantic Hotel. Secretary-Treasurer, J. M. Andrus, 3701 Ravenswood Avenue, Chicago 13, Ill.

CINCINNATI meets fourth Wednesday of each month at 8 P. M. in Engineering Society Headquarters, McMillan Street and Woodburn Avenue. Secretary-Treasurer, H. Roper Davis, Box 2052, Cincinnati, Ohio.

CLEVELAND meets first Friday of each month in Cleveland Hotel at 8 P. M. Secretary-Treasurer, George B. Svenson, 2059 Hamilton Avenue, Cleveland 14, Ohio.

COLUMBUS meets first Friday of each month at 8 P. M. in Battelle Memorial Institute Auditorium. Secretary-Treasurer, Bernard Agruss, 505 King Avenue, Columbus 1, Ohio.

DAYTON meets second Friday of each month in Engineers' Club. Secretary-Treasurer, Elmar W. Rehme, 505 Commercial Building, Dayton 1, Ohio.

DETROIT meets first Friday of each month in Hotel Statler. Secretary-Treasurer, F. L. Clifton, 16536 Inverness, Detroit 21, Mich.

GRAND RAPIDS meets second Friday of each month at 7:30 P. M. in Rowe Hotel. Secretary, Jacob M. Hage, 1327 Jefferson Avenue, S. E. Grand Rapids, Mich.

HARTFORD meets third Monday of each month in Hotel Bond. Secretary, A. J. Dankevich, 63 Massachusetts Avenue, New Britain, Conn.

INDIANAPOLIS meets first Wednesday of each month at Fox Steak House, 1207 Washington Street. Secretary-Treasurer, James J. Monagle, 1464 N. Colorado Ave., Indianapolis 1, Ind.

JACKSON-LANSING meets second Tuesday of each month at Home Dairy Company in Lansing. Secretary-Treasurer, U. J. Forsyth, 1816 Ada Street, Lansing 10, Mich.

LANCASTER meets second Friday of each month at 8 P. M. in Thaddeus Stevens Industrial School. Secretary-Treasurer, H. Clay Brubaker, 881 Manor Street, Lancaster, Pa.

LOS ANGELES meets second Wednesday of each month at 6:30 P. M. in Scully's Restaurant. Secretary, Dean D. Williams, 2728 W. 42nd Street, Los Angeles, Calif.

MELBOURNE, AUSTRALIA. Secretary, L. A. Francis, G. P. O. Box 4502.

MILWAUKEE meets first Friday of each month in Red Arrow Club, 774 N. Broadway. Secretary-Treasurer, James Durnford, 63 Eastman Street, Oconomowoc, Wisc.

MONTREAL meets first Tuesday of each month in Mount Royal Hotel. Secretary-Treasurer, William L. Glover, 754 Second Avenue, Verdun 19, Quebec, Canada.

NEWARK meets first and third Friday of each month at 8 P. M. in Hotel Robert Treat. Secretary-Treasurer, George Wagner, 1130 S. Long Avenue, Hillside, N. J.

NEW HAVEN meets second Tuesday of each month alternating between Sterling Chemistry Laboratory, Yale University, and Hotel Taft. Secretary-Treasurer, B. J. Gaffney, 40 Filbert Street, Spring Glen, Hamden 14, Conn.

NEW YORK meets second and fourth Fridays of each month in Hotel Pennsylvania. Secretary-Treasurer, Franklyn MacStoker, 25 Princeton Street, Garden City, L. I., N. Y.

PHILADELPHIA meets fourth Friday of each month in Harrison Laboratory Building, University of Pennsylvania, 34th and Spruce Streets. Secretary, Paul Mentzer, Sr., 7242 Bingham Street, Philadelphia 11, Pa.

PITTSBURGH meets third Thursday of each month at 6:30 P. M. in Keystone Hotel. Secretary-Treasurer, R. A. Dimon, 210 Semple Street, Pittsburgh 13, Pa.

PROVIDENCE-ATTLEBORO meets third Monday of each month in Providence-Biltmore Hotel. Secretary-Treasurer, Edward A. Parker, 15 Vale Avenue, Cranston 10, R. I.

ROCHESTER meets third Friday of each month in Hotel Seneca. Secretary, James Weaver, 884 Whitelock Road, Rochester 9, N. Y.

ROCKFORD meets second Monday of each month in Faust Hotel. Secretary, Vern T. Wissen, Forest Hills Road, Rockford, Ill.

SAN FRANCISCO meets second Thursday of each month, alternating between El Jardin Restaurant, 22 California Street, San Francisco, and El Curtola Restaurant, 510 17th Street, Oakland. Secretary-Treasurer, Jack Hite, c/o A. A. Plating Works, 1420 Harrison Street, San Francisco 3, Calif.

SPRINGFIELD meets fourth Monday of each month in Hotel Charles. Secretary-Treasurer, L. R. Fountain, 15 Cortland Street, Springfield, Mass.

ST. JOSEPH VALLEY meets first Wednesday of each month at 8 P. M. in Hotel Elkhart, Elkhart, Ind. Secretary-Treasurer, Harold J. Wiesner, 1016 Osolo Road, Elkhart, Ind.

(Continued on page 95)

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Notes on Nickel and Chromium Plating

(Continued from page 33)

curred on anodic areas. Peeling of nickel from an area has been corrected by making the parts cathodic before they entered the plating solution. In Fig. 9a ispictured an erratically plated chromium plated piece. The dull areas were not found on pieces plated after stray current possibilities had been eliminated.

The stray current effect can, however, be turned to advantage. Fig. 12 illustrates an intermediate electrode which we have used in the nickel plating of a part on which it was difficult to get good distribution of current and therefore a uniformly bright deposit. By means of this intermediate electrode a current was guided to the low current density area. Nickel deposited on the cathodic collector plate. Nickel wire was used for the anodic portion since it dissolved quite rapidly. Roughly figured, the stray current density at the wire was about 50 asf.

Bright Copper Undercoatings

The advent of bright copper plating solutions has made it possible, and desirable, to further complicate the plating problem by plating not only nickel and chromium in the same machine but also copper. The latter sequence is particularly useful for die castings. Increasingly the plater is called upon to plan his sequence more carefully and to provide excellent control for all solutions in order to realize the advantages offered by the newly available baths. Changing thought as to what plating quality is coupled with rapidly changing methods which make possible both improved quality and lowered costs demands increasing skill and effort.

Branch Directory

(Continued from page 93)

ST. LOUIS meets second Wednesday of each month in York Hotel. Secretary-Treasurer, E. R. Hunleth, 4415 Michigan Avenue, St. Louis, Mo.

SOUTHEASTERN meets second Thursday of each month in Robert Fulton Hotel, Atlanta, Ga. Secretary, William Weymouth, 173 Clay Street, S. E. Atlanta, Ga.

SYDNEY, AUSTRALIA. Secretary-Treasurer, John Godfrey, P. O. Box 31, Auburn, N. S. W., Australia.

SYRACUSE meets second Friday of each month in Bowne Hall, Syracuse University. Secretary, M. P. Boland, Jr., 211 Rich Street, Syracuse 4, N. Y.

TOLEDO meets first Thursday of each month at Vic Miner Company, 329 20th Street. Secretary, Gaston Bergeman, 703 Pine Street, Fremont, Ohio.

TORONTO meets second Friday of each month in Royal York Hotel. Secretary, Leonard W. Wray, 105 Ronan Avenue, Toronto 12, Ont., Canada.

TWIN CITY meets first Monday of each month, October through June, in Covered Wagon Cafe, Lodge Room, 114 S. 4th Street, Minneapolis. Secretary-Treasurer, Robert L. Buckley, 318 Builders Exchange, Minneapolis 2, Minn.

WATERBURY meets second Friday of each month in Elton Hotel. Secretary-Treasurer, Spencer L. Henn, P. O. Box Dr. B, Cheshire, Conn.

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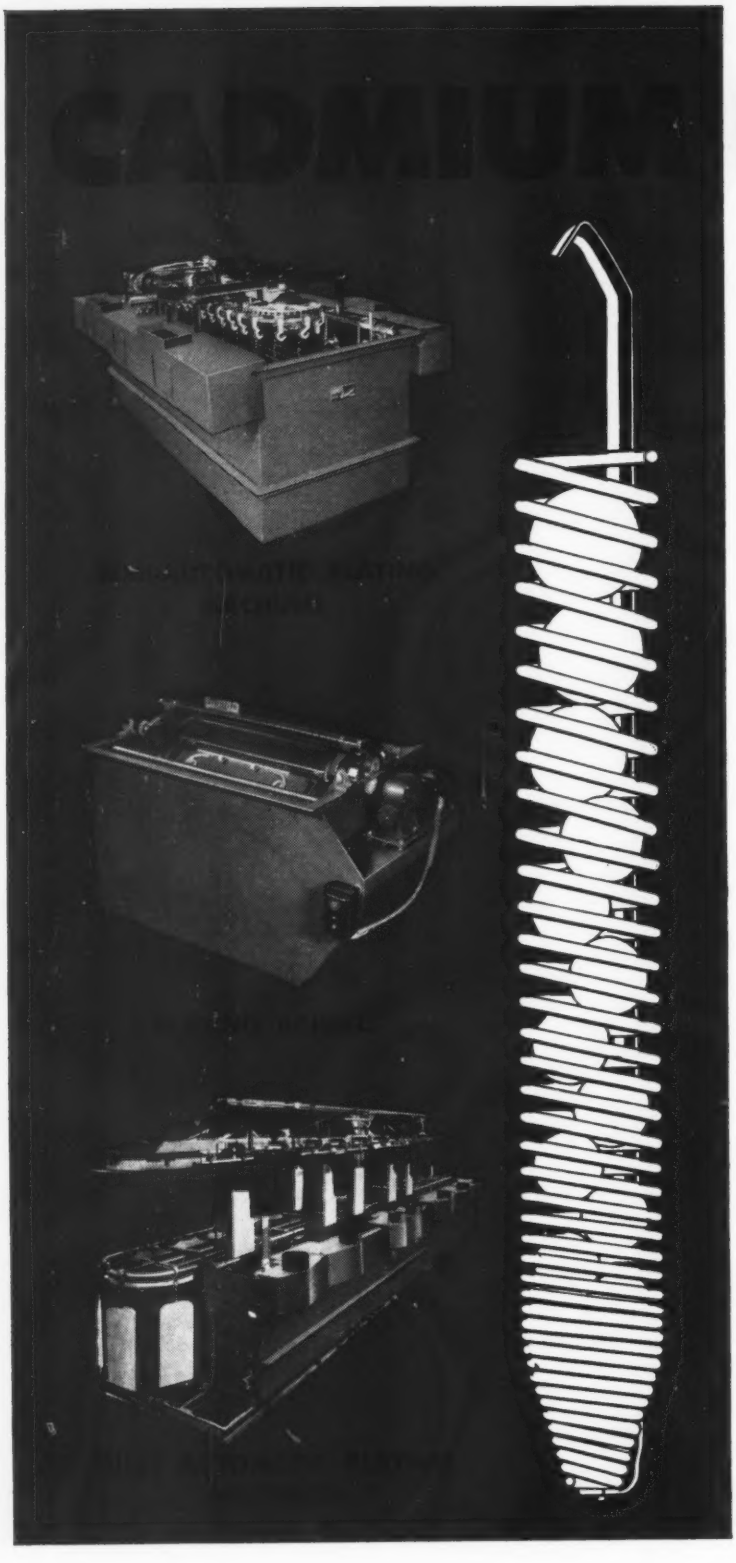

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ZIALITE CORPORATION 95

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Why? *Because it's red*—a dark, deep red-wine color.

That's the famous Michigan Red Coat!

The Michigan Red Coat comes from a special process which covers each grain with *a new tough sharp surface.*

This new surface means—

FASTER-CUTTING, CLEANER-CUTTING AND LONGER-LASTING ABRASIVE BELTS *FOR YOU!*

Demand Michigan Red Coat Belts today!

(If you can't get Michigan Red Coat Belts, mail us this ad and your address.)

Plus—

DISCS, ROLLS, SHEETS AND LAPPING COMPOUNDS

Michigan Abrasives are supplied in Belts, Discs, Rolls and Sheets—either paper or cloth backed —and in Silicon Carbide, Aluminum Oxide and Garnet—in full range of standard grit sizes.

Michigan Abrasive Lapping Compounds are tops in their field—come in 13 standard grits in Silicon Carbide.

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MICHIGAN ABRASIVE CO.
1111 BELLEVUE AVE. • DETROIT 7, MICH.
Phone: MElrose 3131

Metal Polishing

(Continued from page 37)

places seem to agree on what constitutes a particular size of grain, i. e., one supplier's 120 grit is equivalent to another supplier's 90 grit. This condition used to apply in America in the early days, but I understand that latterly the U. S. grain has been standardized so that it can be depended upon. For this reason care should be exercised when placing large orders for grain.

There are two classes of abrasives, natural and artificial. The artificial abrasives consist of either aluminum oxide or silicon carbide. Silicon carbide is rarely employed on polishing wheels, but aluminum oxide is used extensively.

Both aluminum oxide and natural emery have their uses in the polishing shop: the former is ideal for rough work which does not require a high finish and from which it is necessary to remove a fair amount of stock; the latter is better for jobs requiring a high finish and for which 90 grit and finer is used.

Natural emery is not as fast cutting as artificial abrasive, and the grains have a tendency to break down in use, thereby tending to produce a progressively finer finish.

FUTURE MEETINGS

CHICAGO BRANCH, A. E. S. Annual Educational Session and Banquet in Hotel Stevens on January 24.

GRAND RAPIDS BRANCH, A. E. S. Annual Educational Session at 2:00 P. M. and Dinner-Dance at 7:00 P. M. in Pantlind Hotel on January 24.

AMERICAN SOCIETY FOR TESTING MATERIALS. Committee Week and Spring Meeting in Hotel Statler, Washington, D. C., on March 1–5.

CHICAGO PRODUCTION SHOW in Stevens Hotel on March 22–24, sponsored by Chicago Technical Societies Council, 53 W. Jackson Boulevard, Chicago 4, Ill.

THE ELECTROCHEMICAL SOCIETY. Spring Conference in Deshler-Wallick Hotel, Columbus, Ohio, on April 14–17.

BOSTON BRANCH, A. E. S. Annual Meeting, on April 17.

AMERICAN CHEMICAL SOCIETY. 113th National Meeting on April 19–23 in Chicago, Ill.

AMERICAN SOCIETY FOR TESTING MATERIALS. Annual Meeting and 8th Exhibit of Testing Equipment and Related Apparatus in Book-Cadillac Hotel, Detroit, Mich., on June 21–25.

AMERICAN ELECTROPLATERS' SOCIETY. 35th Annual Convention and Industrial Finishing Exposition in Ambassador Hotel and Atlantic City Auditorium, Atlantic City, N. J., on June 28–July 1.

THE ELECTROCHEMICAL SOCIETY. Fall Conference in Hotel Pennsylvania, New York City, on October 13–16